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DIAGNOSIS AND DIFFERENTIAL DIAGNOSTIC DATA ON SPECIFIC TYPES OF SUPPURATION IN THE PETROSAL PYRAMID

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Suppuration in the petrosal pyramid is found to occur in two forms. In one, an osteomyelitic lesion develops in the bone, and in the other, coalescent osteitis is present. The symptoms which present themselves differ essentially in the two types of lesion; and in order to make a diagnosis it is necessary to differentiate these forms clinically. It is therefore necessary to touch on the pathologic entities of these infections so as to comprehend their varying clinical courses and differing clinical pictures. Both these lesions are found to accompany or follow an infection of the tympanic cavity.

According to Ramadier, one deals with two forms of osteomyelitic lesions in the petrosal pyramid. One form is termed hematogenic, and the second form, otogenic. The former is most frequently present in the very young patient. The clinical picture is one of general infection. There is marked prostration; there are gastro-enteritic disturbances, and often the signs of pulmonary involvement cloak the advance, step by step, of the infection as it infiltrates the diploic bone, with its contained bone marrow, in the petrosal pyramid. Otitic phenomena are present, but the signs and symptoms from the middle ear do not dominate the clinical picture. Eventually, and almost inevitably, the lesion reaches the endocranial structures, and the final picture is that of meningitis. One significant characteristic has been established: The lesion is usually bilateral.

Otogenic osteomyelitis, on the other hand, more clearly takes a course which shows it to be a sequela of otitic infection. This form of osteomyelitis is not confined to infancy or childhood. It occurs usually in the course of suppuration of the middle ear. Its onset most often takes place after the initial acute phase of the suppurative otitis assumes a subacute status. Nevertheless, its onset is marked by acute signs. Suddenly, in the course of an attack of otitis which has seemingly subsided into a prolonged course of otorrhea, there are violent auricular, periauricular and hemicranial pains on the side of the head

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from which there is a discharge from the middle ear. The infection of the tympanic cavity simultaneously shows an increased intensity, and the discharge from the middle ear becomes more profuse. The temperature ranges from 100 to 102 F. Sleep is disturbed, and often edema appears over the area of the upper attachment of the auricle. The walls of the external canal become edematous and painful to the touch. This tenderness of the periauricular region is in marked contrast to the absence of the usual signs of tenderness of the mastoid process. The painful edematous swelling spreads to the surrounding region, and inflammatory processes become evident in the upper cervical, the occipital and the temporomaxillary region. The complicating lesions which may occur are metastases involving the lungs in a bronchopneumonic process or secondary foci of infection almost anywhere in the body. If they are allowed to progress uninterruptedly death ensues from sepsis, pulmonary complications or meningitis.

Helpful toward furnishing diagnostic data is the use of roentgen films. These show a diploic type of bone structure and locate areas of decalcified bone in the petrosae and often in the zygomatic areas. When evidence of the spread of the lesion is thus presented as being in the squama or in the adjacent bone tissue of the occipital or parietal bone, the diagnosis of the lesion becomes positive roentgenologically. When this evidence is accompanied by a clinical picture similar to that already outlined, the diagnosis is established.

The remaining form of lesion of the bone in the petrous portion of the temporal bone is that of coalescent osteitis. This occurs only in pneumatized bone. Its development as a lesion parallels the mechanics of evolution as they enroll themselves in the mastoid process. Owing to the fact that within the petrosal pyramid there is located the compact bony capsule of the labyrinth with its contents, the cellular elements spreading out from the tympanic and the epitympanic spaces reach above, below and behind the labyrinth to merge in an irregular manner at the deepest portion of this bone near the so-called tip.

Coalescent osteitis of the petrosal bone is a complication of infection of the middle ear, just as is coalescent mastoiditis. Often the margins of these tracts of purulent cells break their way outward toward the tympanum and epitympanum and into the cavity of the mastoid wound, and are found as one or more fistulas. Since the development of this lesion is marked by the dominating signs and symptoms of coalescent mastoiditis, mastoidectomy has generally been performed long before the characteristic signs and symptoms of petrosal suppuration supervene.

The diagnosis of the coalescent type of petrositis resolves itself into: (1) the determination of its presence; (2) the determination of the location within the petrous perilabyrinth; (3) the evaluation of the clinical picture so that the proper management of the case becomes clear,

and (4) the exclusion of any other condition which might produce one or another of the findings in the symptom complex.

It is fairly definitely established that the most constant sign of petrositis is pain in the first branch of the fifth nerve, as represented by intra-orbital and supra-orbital pain. At one time or another in the development of the lesion this symptom presents itself. It is constantly present in all acute and subacute types of petrositis. It disappears when adequate drainage for the deep-seated focus is afforded either spontaneously or by surgical intervention. The next constant symptom is the continuation or recurrence of a purulent process from the tympanomastoid region. Finally, in all cases there is a mild fever which assumes a moderately septic course.

When this triad of symptoms presents itself in the course of otitic suppuration, either prior or subsequent to surgical intervention, the condition must be tentatively diagnosed as petrositis. The otologist is then confronted with the problem of differentiation between lesions outside the temporal bone and those which, confined to the petrous perilabyrinth, may occupy one or several areas within the petrosa. Pain in the eye is sometimes noted in cases of thrombosis of a sinus, meningitis of the anterior fossa, and abscess of the brain, particularly in the temporosphenoid lobe, and of course it is a common finding in cases of involvement of the sphenoid and frontal sinuses. The definite clinical picture of septic sinus thrombosis plus the information obtained by repeated blood counts and blood cultures makes this lesion easy to diagnose. Meningitis, particularly when located in the anterior fossa, may not at first give the clinical signs common to generalized purulent leptomeningitis and in its earlier stages may present only severe supra-orbital or frontal headache. However, the pain is more often than not distributed over the entire frontal area and is rarely limited to the intense unilateral supra-orbital pain of petrositis.

Observation of the increase in the spinal fluid pressure and the early comparison of the results of chemical tests for lactic acid, chlorides and carbonates of the cerebrospinal fluid with the results of tests for the same constituents in the blood stream afford an early means of differentiation between meningitis and petrositis.

Deep-seated suppuration in the temporosphenoid lobe, particularly when located in areas which give no focalizing signs, is often difficult of diagnosis in the early stages. In this condition, however, the pain from the first branch of the fifth nerve does not assume a typical nocturnal character, as in petrositis; it is most often of an intractible type and present throughout the day. Furthermore, it is not associated with a recrudescence of otorrhea. The involvement of the nasal accessory sinuses can, of course, be readily determined by inspection and by the use of the roentgen rays.

After the otologist has successfully ruled out the aforementioned conditions and has corroborated his clinical diagnosis of petrositis roentgenographically by means of base plates and views taken with the patient in the Stenver position, it becomes incumbent on him to attempt to localize the lesion in the perilabyrinth. This is of the utmost importance, since the various localities require different modes of therapy, and if operation is to be undertaken the exact seat of the petrosal lesion must be known so that unnecessary surgical procedure may be avoided.

When it is comprehended that the petrous bone not only houses the labyrinth but is itself surrounded by, and is in relationship to, many structures which when irritated or involved are capable of causing symptoms, it becomes readily apparent that certain areas, when involved, will, in addition to the triad already mentioned, give further signs and symptoms which will be helpful in localizing the lesion within the perilabyrinth.

Almour has suggested a nomenclature wherein he distinguishes petrositis which occurs posterior to the plane of the superior semicircular canal and that which occurs anterior to this plane. He calls the former posterior petrositis and subdivides this into posterosuperior, postero-inferior and postero-internal petrositis. The anterior group of lesions is further subdivided into the supracochlear, infracochlear, pericarotid, peritubal and encapsulated lesions of the apex commonly termed apicitis. In general, posterior petrositis should be suspected when, in addition to pain in the eye, protracted tympanomastoid discharge and low grade sepsis, there appear transient vertigo, transient nystagmus and nausea. These symptoms are due to mild irritation of the semicircular canals. Anterior supracochlear petrositis frequently causes transient facial paralysis in addition to the general symptoms. Infracochlear petrositis may give rise to disturbances of the vagus nerve because of its proximity to the jugular fossa. Finally, in all cases of anterior petrositis profuse purulent otorrhea is present, which continues to progress while the mastoid disease rapidly heals.

On the other hand, petrositis in the posterior position always causes a discharge from the mastoid wound, which shows no evidence of healing; and in certain types, namely, the postero-internal and postero-inferior, there is complete healing of the tympanic cavity with an intact drum.

Once the location of the perilabyrinthine focus has been determined, it becomes incumbent on the otologist to determine the type of surgical intervention indicated. The presence of fistulous openings in any of the aforementioned areas should be identified, and if drainage is adequate no further operation is required. When drainage is inadequate, however, as evidenced by recurrence of the pain and by loss of weight, anorexia, malaise and listlessness, isolation of the fistulous tract, its

widening and curettage of its depth are required for proper evacuation of the pus in the perilabyrinth. Fistulous tracts in the posterior perilabyrinth are exposed through a simple mastoidectomy wound. Those located in the anterior perilabyrinth, however, require radical exposure of the tympanic cavity in order to be reached. When a fistulous tract is not demonstrable and when the case is one of encapsulation of pus within the apex of the petrous pyramid, a specialized technic, such as that devised by Eagleton, Ramadier and Almour, is necessary to evacuate the pent-up pus.

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ABSTRACT OF DISCUSSION

Dr. J. A. Sullivan, Toronto, Canada: In three cases of coalescent osteitis of the petrosal pyramid palsy of the sixth nerve occurred in one, and it was evident only when the lesion became extrapetrosal. Base plates made at the beginning of the infection are invaluable aids for comparison, record and help in diagnosis, irrespective of normal variations. All the lesions occurred in pneumatized bones. A complete radical simple mastoidectomy should be carried out as a routine in all cases. My three patients have defective hearing. The histologic structure of the petrosal pyramid determines the type of clinical entity ensuing when the pyramid is subjected to infection which results in a pathologic process. Ramadier's classification of osteomyelitic lesions, especially the otogenic lesions, is important. The roentgenogram showing diploic bone with areas of decalcification in the pyramid, zygoma and adjacent bones, coupled with the clinical picture, offers a valuable contribution in establishing a diagnosis. The anatomic division of the pyramid by the plane of the superior semicircular canal into anterior and posterior groups of cells offers a comprehensive means of orientation. With the clinical interpretation of a lesion in the division I cannot agree. The problem of a given case postulates the type of therapy. No one surgical approach is adequate or sufficient for all cases. Encapsulation of pus within the apex of the petrous pyramid demands surgical drainage, if possible within the confines of the temporal bone. Aural surgery is a part of the great science of surgery, and the words aural surgery are in many places designedly employed instead of the word otology. I accept the fundamental surgical principle which states that pus must be drained at its most dependent point in a rational manner, which must be adequate.

Dr. Henry K. Taylor, New York: I wish to emphasize the roentgen findings. In doing so I limit myself to two descriptive terms or phrases: (1) an increase in density and (2) a decrease in density. An increase in density means that a structure appears more white in a roentgenogram. It has gained something. In a pneumatic bone anything that decreases the contact with air produces an increase in density. This may be accomplished by congestion of the mucous membrane, by a transudate or an exudate in the air spaces or by a combination of the two. It can also be accomplished by the development of new bone and an increased deposit of lime salts. The reverse holds true when a decrease in density is described. Something has been removed, usually calcium and its supporting structure. The area involved appears darker on the roentgenogram. By observation of these two changes and correlation of the clinical findings it is possible to diagnose (1) a suppurative lesion in the petrous apex which requires immediate surgical intervention as a life-saving measure, (2) a suppurative lesion in the

petrous apex which does not require immediate surgical intervention as a life-saving measure and (3) a suppurative lesion in the petrous apex, the site of the infection being protracted otorrhea. In the first and second instances one finds a decrease in density in the petrous apex. This is due to a destructive lesion, the breaking down of trabeculae and the removal of lime salts. This change is limited to the petrous apex mesial to the labyrinth. To detect this change I prefer a roentgenogram of the base of the skull. In the third instance one finds an increase in density in the petrous apex. This is a reactive change—productive osteitis, formation of new bone, a sclerosing process which is secondary to the low grade infection. In all three instances the labyrinthine and basal portions of the pyramids show an increase in density, which is due to congestion of the mucous membrane and the fluid content of the pneumatic spaces. With the exception of neoplasms and aneurysms I know of no condition other than a suppurative lesion in the petrous apex which produces a decrease in density. An increase in density in the entire petrous pyramid is observed with any otitic infection. The increase in density of the entire petrous pyramid which attends an otitic infection does not warrant the diagnosis of petrositis unless the history indicates protracted otorrhea. The healed stage or end-stage of a suppurative lesion in the pyramid presents on roentgenographic examination a pyramid that shows an increase in density and resembles the pyramid found in a case of protracted otorrhea. When a complication is suspected the roentgen examination should include, in addition to the mastoid area, the petrous pyramids in a view of the base of the skull taken with the patient in the Stenver or a similar position. Not all complications to mastoid infections are located in the petrous apex. The additional views may help in locating, among other conditions, an epidural abscess near the petrous apex.

Dr. Ralph Almour, New York: I wish to call attention to the type of petrosal suppuration which results in chronic discharge from either the tympanic cavity or the middle ear. In these cases there are not the typical findings or symptoms that are seen in acute or subacute cases. Following mastoidectomy for an acute lesion, the patient may complain of slight pain in the eye for a day or two, and then the course may be symptomless except for a persistent discharge from either the mastoid wound or the middle ear or both. The case does not present any of the evidences associated with chronicity; the perforation is not of the marginal type. The lesion which has taken place in the pneumatic bone was not preceded by scarlet fever; so acute necrotic otitis can be ruled out. With every diagnosis eliminated, a roentgenogram will give evidence of a suppurative focus within some portion of the perilabyrinth. The lesion will continue to be present; the discharge will continue, and the wound will not heal until the focus has been thoroughly eradicated. In such cases large, wide-mouthed fistulas are present, and because of this drainage is adequate and pressure of pus does not give rise to symptoms. If the discharge is only from the mastoid process, simple revision of the mastoidectomy wound will uncover the fistula. If the discharge is wholly from the middle ear, radical mastoidectomy becomes necessary to disclose the orifice. Curettage and drainage of this will result in cessation of the otorrhea.

Dr. Simon L. Ruskin, New York: In my paper on the venous circulation of the petrous bone I showed that the diagnosis of petrosal involvement could be made long before suppurative symptoms appear. I was able to point out that the venous circulation of the apex of the petrous bone is related to the venous circulation of the tympanic cavity, that the veins of the posterior portion of the petrous bone and of the posterior part of the tympanic cavity drain into the inferior

petrosal sinus and that when congestion becomes sufficient that the distention in the inferior petrosal sinus exerts pressure in the canal of Dorello on the abducens nerve and produces paresis of the nerve, which Gradenigo has described. I also showed that the veins of the anterior portion of the petrous bones and the veins of the anterior portion of the tympanic cavity eventually drain into the pterygoid plexus, and another symptom is produced, which I have designated as edema of the lower lid. These manifestations appear early, indicate early inflammatory involvement, are transient, are passed over and do not receive the attention they deserve. In two of Dr. Kopetzky's cases a child had edema of the lower lid on the side where the petrosal symptoms developed later; every time the edema appeared the symptoms became worse. These early symptoms do not occur with mild fever; usually there is an elevation of temperature to 103 and sometimes to 104 F. During this period of congestion, if congestion of the petrous bone is relieved by repeated paracentesis there is a remarkable change in symptoms; in a case I reported for Dr. Harold Hays the relief from the symptoms was amazing. I am glad to note that Dr. Kopetzky has emphasized that petrosal involvement can be divided into posterior and anterior petrositis, and I hope that recognition will be given to my previous description of this in my paper on venous circulation. If the early stage passses unrecognized, after a period of time there are evidences of coalescence of bone, and whether osteomyelitis or coalescent mastoiditis occurs depends on the type of bone. Also, the symptoms of pain in the orbit are readily understood when the congestive areas are recognized. Dr. Kopetzky has lifted much of the mysterious haze about the operation introduced originally. According to Wolf's early work, the petrous bone includes a disk of bone covering the antrum and the attic which acts like a lid to the petrous bone. As soon as a thorough, complete radical mastoidectomy is carried out the petrous bone has been uncapped. Some specimens show a horizontal suture on the mastoid a little below the level of the antrum indicating the plate. After the petrous bone is uncapped a simple investigation of the area of the invasion indicates an adequate approach.

Dr. Samuel J. Kopetzky, New York: There is a sincere effort all through the country, as evidenced by the discussion here and elsewhere as well as those which have taken place in the booth in the exhibit hall, to comprehend this newer conception of a clinical entity. As to the theories based on the hypothetic reasoning of the last speaker I have not the time to show his errors in deduction, the wrong premises on which his reasoning is based and the total lack of clinical experience which he evidences in the diagnosis of this lesion; so I must postpone the pleasure that both Dr. Ruskin and I would feel in a protracted discussion of the topic from this standpoint.

"AURAL" OR "ACOUSTIC" METHOD OF TREATING DEAFNESS

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Conflicting reports in the literature as to the value of the "aural" or "acoustic" method of treating deafness have stimulated us to make a careful investigation of a recent device constructed on the principle of the radio.

Urbantschitsch,[1] of Vienna, in the early nineties made what was probably the first systematic attempt at "auditory reeducation," or stimulation by means of sounds. He used the voice and accordion to accomplish this reeducation. Other experimenters have used sirens, phonographs, diapasons and other instruments, usually musical, with indifferent results.

In 1910 Zünd-Burguet,[2] of Paris, described an instrument, devised by him, actuated by an electric current of from 4 to 6 volts and containing three organs producing tones with harmonics similar to and within the range of the human voice. The pitch and intensity of the sounds produced could be regulated. Transmission of the sounds to the ear was accomplished by means of modified telephonic conductors.

Zünd-Burguet referred to the favorable report of Dr. John Helsmoortel of Antwerp, Belgium, presented to the Royal Academy of Medicine of Belgium with some thirty "duly controlled clinical observations that auditory reeducation according to Zünd-Burguet's method had brought about quite remarkable results."

The principal exponent of this method in England has been Cathcart,[3] who in 1925 reported a definite improvement in 68 per cent of his patients with deafness of various types. He[4] also claimed that

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1. Urbantschitsch, cited by Yearsley[5a] and by Salinger.[7]

2. Zünd-Burguet, A.: La rééducation auditive d'après la méthode électro-vociphonique, Arch. internat. de laryng. **30**:140, 1910.

3. Cathcart, G. C.: Alleviation of Chronic Progressive Deafness: A Record of One Hundred Cases Treated by the Zünd-Burguet Electrophonoide Method, Lancet **1**:968, 1925.

4. Cathcart, G. C.: Alleviation of Chronic Deafness, Practitioner **124**:142, 1930; Seven Patients Illustrating Alleviation of Deafness and Tinnitus by Zünd-Burguet Electrophonoide Method, Proc. Roy. Soc. Med. **27**:897, 1934. Tod, H. F.: Diseases of the Ear, New York, Oxford University Press, 1926.

tinnitus could be cured or alleviated by this method of treatment. Another exponent is Yearsley,[5] who in 1932, in discussing the results of treatment in two hundred cases in which that treatment was used since 1925, stated that it is "a valuable method in a large number of cases of deafness."

Various conflicting reports by other observers[6] who used this machine have appeared since 1927.

The advent of the radio has given new impetus to the idea of using sounds as a means of reeducating or stimulating the deafened ear. Salinger[7] in 1925 reported the observations before and after treatment on sixteen partially deaf persons. The instrument used was a tone amplifier built on the principle of a radiophonograph. The theory by the promoters was that "no matter how far gone the hearing apparatus may be, there is still an appreciation for sound either in the nerve apparatus or in the brain, which can be reached if the proper stimulus be applied." The intensity of sound is increased to the threshold of audition, and by continuing the stimulus the acuity of hearing is supposed to be developed. Salinger's patients received from twelve to sixty treatments each during a period of from three to ten weeks. Of the sixteen patients, two showed improvement; in eight the hearing was worse, in two there was no change, and in four the results were doubtful. The results can be classified as decidedly unsatisfactory.

Shambaugh[8] in 1932 reported adversely on the results of giving to ten patients from the League for the Hard of Hearing ten or more treatments with a machine similar to the one used in this investigation. He stated that he was unable to discover any alteration in the hearing that did not fall well within the limits of the normal variation encountered in charting the audiometer findings.

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5. Yearsley, M.: (*a*) Electrophonoide Treatment of Deafness, Practitioner **117**:292, 1926; (*b*) Case of Aural Vertigo Successfully Treated by Zünd-Burguet Method, ibid. **119**:101, 1927; (*c*) Manual of the Electrophonoide Method of Zünd-Burguet, London, William Heinemann, Ltd., 1927; (*d*) Zünd-Burguet Method in Children, Lancet **2**:1285, 1927; (*e*) Anomalous Case of Deafness Successfully Treated by Electrophonoide Method, Brit. J. Child. Dis. **25**:116, 1928; (*f*) Further Observations on Electrophonoide Treatment of Deafness, Practitioner **128**:631, 1932.

6. Bana, F. D.: Electrophonoide Method of Treating the Deaf, Indian M. Gaz. **62**:324, 1927. de Parrel, G.: La rééducation auditive. Indications et contre-indications, Clinique, Paris **23**:357 (Oct.); 379 (Nov.) 1928. Bettington, R. H.: Treatment of Deafness by Zünd-Burguet Method, M. J. Australia **2**:366, 1930. Brown, R. G.: Treatment of Deafness by Zünd-Burguet Electro-Phonoide Method: Summary of Forty Consecutive Cases, ibid. **1**:375, 1931. Pruvost, M.: La rééducation electrophonoide des sourds, Echo méd. du Nord **37**:296, 1933.

7. Salinger, Samuel: The Treatment of Deafness by the "Acoustic Method," Arch. Otolaryng. **1**:397 (April) 1925.

8. Shambaugh, G. E.: The Oratone, J. A. M. A. **99**:1102 (Sept. 24) 1932.

Howard A. Carter,[9] secretary of the Council on Physical Therapy of the American Medical Association, reports that the device used in this investigation is essentially an electrical oscillator which is a variation of a well known radio hook-up. Electrical energy from a power amplifier is conducted to a system of reactance coils and condensers, thus generating an oscillating current. This oscillating current, the tone current, is conducted to a set of specially constructed telephones which clamp tightly over the ears. By varying the inductance and the capacity, the frequency of the tone in the ear phones may be varied. A dial on the cabinet indicates arbitrarily the frequency, and a second dial indicates the loudness, of the tone. The tone energy may be directed by a switch to the right ear, the left ear or both.

When the unit is used as a diagnostic device, the dials are set at progressive points, thus providing a large selection of frequencies. The intensity of the loudness is controlled by a dial which progressively increases its amplitude.

When the unit is used as a therapeutic device, the dial recording the frequency may be directly connected with a motor-driven unit which automatically rotates the dial slowly, first one way and then the other. The tone varies gradually from one frequency to another through the limits of the range of the machine.

The treatments with this instrument as given by Mr. Patterson, an experienced operator of the device, consisted in running an ascending and a descending scale of musical tones determined by the limits of the machine, that is, from a low frequency of about 124 to a high frequency of about 2,000 vibrations per second.

This investigation, covering a period of ten months, consisted in giving a total of 777 treatments to both ears[10] of twenty-five partially deaf persons. An average of 31 treatments were given to each patient. The cases of deafness were not selected but were taken consecutively as the patients applied to the clinic. An examination was made of each patient, and the type of deafness was noted. No patient with an acute condition was selected. All had had difficulty in hearing for some time. A diagnosis of nerve type deafness was made for fourteen of the patients; three had otosclerosis; one patient seemed to have a combined otosclerosis and chronic middle ear deafness; three had a mixed type of deafness, that is, partial nerve deafness and partial chronic adhesive otitis media. Two patients had chronic middle ear deafness. One patient had had a sudden attack of deafness, tinnitus and vertigo resembling Ménière's syndrome. One other patient had nerve deafness of twenty-five years' standing with a sudden onset which had been accompanied by symptoms of Ménière's

9. Carter, Howard A.: Personal communication to the authors.

10. In two instances the right ear only was treated.

syndrome. All the patients were adults, their ages ranging from 25 to 76 years; the average age was 49 years.

An effort was made to give the treatments or "exercises" three times a week. Some of the patients came twice a week, and some attended intermittently.

The acuity of hearing in each ear as determined by the 2-A audiometer was charted for each patient before treatment was begun. Additional charts were made at intervals of about every ten treatments. A special effort was made to exercise the areas of more marked deafness. The volume was determined by the amount of loss of hearing; however, care was taken to give only the amount of volume which could

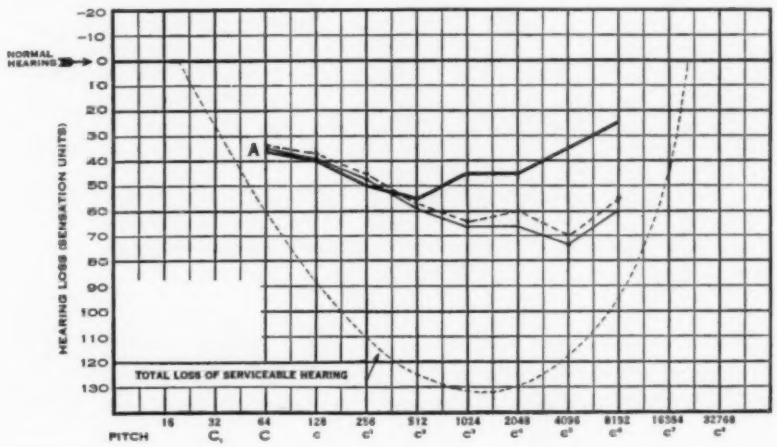

Chart 1.—Average of results of examination of twenty-five patients before treatment was begun. The solid line indicates the results of examination of the right ear, and the line of dashes, the results of examination of the left ear.

be tolerated by the patient without discomfort, as former experiences indicated that a detrimental result might follow the use of excessive amplitudes.

Chart 1 shows the average of the results of examination of twenty-five patients before treatments were begun. Chart 2 shows the average of the results of examination of the same patients after they had received from ten to seventy-seven treatments each.

An average of the various frequencies heard in both ears before treatment as compared with an average of the frequencies heard in both ears at the end of the period of treatment gives an average loss of 3¾ sensation units for each frequency of from 64 to 8,192 vibrations per second inclusive.

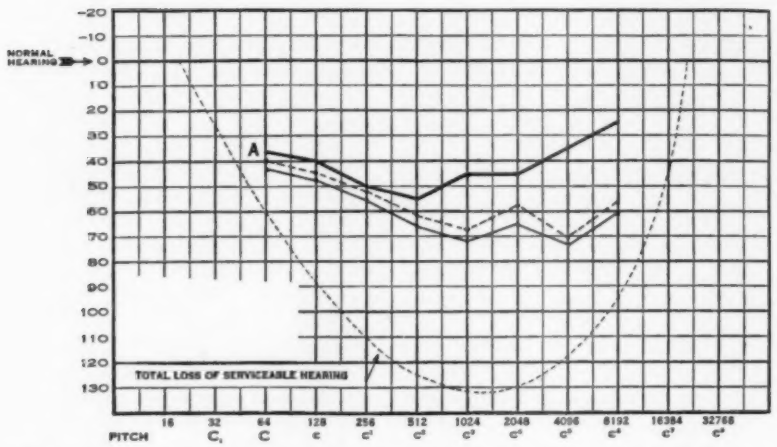

Chart 2.—Average of results of examination of twenty-five patients after they had received from 10 to 77 treatments each. The solid line indicates the results of examination of the right ear, and the line of dashes, the results of examination of the left ear.

Results of Treatment in Twenty-Five Patients

Case	Age	Diagnosis	Length of Deafness	Number of Treatments	Average Change After Treatments, S. U.	Change in Tinnitus After Treatments
1. D. H.*	35	Otosclerosis	Many years	10	+ 2	No change
2. J. S.	49	Otosclerosis	Many years	10	—½	
3. T. F.	65	Nerve and chronic middle ear deafness	2 years	13	—21	
4. J. M.	49	Nerve deafness	Many years	16	—13	
5. M. W.	25	Chronic middle ear deafness	1 year	16	+ 8½	
6. C. G.	45	Nerve deafness	5 years	17	—26	
7. P. P.	49	Nerve deafness	14 years	20	— 7	No change
8. C. B.	64	Nerve and chronic middle ear deafness	1½ years	20	No change	
9. C. A.	46	Ménière's syndrome	3 weeks	23	—19	Better
10. A. H.	40	Nerve deafness	15 years	24	+ 2½	
11. E. W.	41	Nerve deafness	5 years	25	—24	Worse
12. E. H.	29	Nerve and chronic middle ear deafness	15 years	26	—10	Worse in right ear
13. A. H.	60	Nerve deafness	Many years	29	— 3	Better
14. T. C.	67	Nerve deafness	40 years	30	— 2	
15. J. R.	45	Chronic middle ear deafness	2 years	31	+ 9	
16. B. N.	55	Nerve deafness with recent acute suppurative otitis media in the left ear	12 years	32	+12	
17. E. J.	48	Nerve deafness	45 years	38	— 7½	
18. E. V.	32	Otosclerosis and chronic middle ear deafness	Few years	38	— 3	Worse
19. T. D.	48	Nerve deafness	10 years	41	— 3	Worse
20. J. S.	60	Nerve deafness	5 years	42	—31	
21. M. B.*	35	Nerve (Ménière's syndrome)	25 years	42	— 1	
22. W. F.	61	Nerve deafness	25 years	45	No change	No change
23. M. O.	45	Otosclerosis	15 years	55	— 6	Better
24. W. R.	76	Nerve deafness	10 years	57	—11½	Better
25. O. O.	40	Nerve deafness	Many years	77	—13	Better

* The right ear only was treated.

At the end of the period of treatment five of the patients showed improvement amounting to from 2 to 12 sensation units. In cases 1 and 10 (table) the improvement amounted to 2 and 2½ sensation units, respectively. This change is so slight as to fall within the normal range of variation, and as a result may be considered without significance.

In cases 5 and 15 there was an average improvement of 8½ and 9 sensation units, respectively. These patients both had chronic middle ear deafness of one year and two years, respectively. Improvement in hearing in middle ear deafness is more rapid and more likely to occur spontaneously than in otosclerosis or in nerve deafness. As a result improvement in these cases does not have great significance, especially as in four other cases (cases 3, 8, 12 and 18) in which middle ear deafness was present no change in or loss of hearing resulted.

The greatest improvement (12 sensation units) occurred in case 16. This improvement was confined to the left ear. At the time of the first examination this patient stated that she had had acute suppurative otitis media in the left ear three weeks before. At the time of the first examination the left tympanic membrane was still red, but no secretion or perforation was present. Improvement of hearing in that ear should be attributed to normal subsidence of the inflammation, especially as all the improvement occurred during the first ten treatments and no material change was observed thereafter, although the patient received a total of fifty-five treatments.

Ten patients returned for a final check-up from four to ten weeks after the completion of the course of treatment. No material change was found. What change there was consisted in a continued slight decrease in the average acuity of hearing. This was to be expected as the majority of the patients in this series appeared to suffer from a progressive type of deafness.

From this study it is concluded that the "aural" or "acoustic" method of treating deafness has not proved of value in the cases forming the basis of this investigation.

TREATMENT OF HAY FEVER AND HYPERESTHETIC RHINITIS BY IONIZATION

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Electro-ionic medication or medical ionization, properly called iontophoresis, was much in vogue thirty years ago. Then its use subsided until Warwick reported the successful results he obtained by using that method. Medical ionization is the introduction of ions into the skin or mucous membrane by means of the galvanic current.

APPARATUS AND ACTION

The galvanic current can be produced by several methods, namely: 1. By batteries which give a pure constant current. This set-up has been made for years by different manufacturers. An inexpensive set has recently been described by Macfarlan.[1] 2. By the galvanic wall plate in which the power line is direct current. 3. By the motor generator.

The report on tests of three apparatus by the Westinghouse laboratory is as follows:

1. *Wappler Wall Plate.*—This device operates from the direct current supply, and the output, therefore, takes on the character of the direct current from the power mains. As the ripple in the majority of power systems is entirely negligible, the galvanic output of this machine is similar to the output from a battery as regards ripple.

2. *Burdick Galvanic Generator.*—This device consists of a motor generator set; hence the output has the characteristics of the generator rather than of the current from the power lines. Measurements made on an oscillograph showed that the output up to about 30 milliamperes was almost entirely without ripple, the ripple being so small that it could not be measured with the laboratory equipment used in the tests.

3. *Another Make of Galvanic Generator.*—This machine also contains a motor generator set; hence the current delivered has the characteristics of the generator. The output of the generator has a considerable amount of ripple, the percentage varying with the milliamperage of the machine. With small outputs the percentage of ripple is quite small, but it increases when the direct current milliamperage increases. Oscillograms made at an output of 30 milliamperes show a ripple content of approximately 8 per cent. The frequency of this ripple is 1,080 cycles per second.

Read before the American Laryngological, Rhinological and Otological Society, Toronto, Canada, June 5, 1935.

1. Macfarlan, Douglas: Ionization: Circuit Plans for an Inexpensive Unit, Arch. Otolaryng. **21**:456 (April) 1935.

Each type of apparatus has its adherents. It probably makes no difference which type is used, as clinically the patients have about the same degree of discomfort and the appearance of the membrane and the results are the same, no matter which apparatus is chosen.

The current is unidirectional, of low voltage and amperage. The positive pole repels hydrogen, alkalis and metals, and a convenient way to remember this is by means of the initials "H. A. M. P.," indicating "hydrogen," "alkalis," "metals" and "positive" pole, respectively. The negative pole repels acid, acid radicals and halogens. The galvanic current produces two effects; (1) physiochemical and (2) physiologic. The effects manifest themselves at the point of entry and exit and also along the path of the current between the poles.

The effect at the poles is simple, but what takes place along the path of the current through the body is still undetermined and is subject to much controversy. If the two terminals are metallic plates and are placed against the wet skin, caustic effects result, namely, the sodium chloride of the body fluid breaks up into caustic sodium hydroxide at the negative pole and hydrochloric acid at the positive pole. To overcome this destructive action both poles, metallic terminals, must not come in direct contact with the skin or mucous membrane but must be separated by a pad of cotton or by the electrolyte. The pads must be sufficiently thick so that the caustic chemicals from the metallic poles cannot diffuse to reach the skin and mucosa.

As the current flows through the body many complex factors come into play besides the action on the sodium chloride. In the body there are also colloids and other metals and acids. There must be migration, or at least redistribution, of ions in the body between the poles, but if the current is kept within physiologic limits there are no demonstrable physiologic effects.

ELECTRO-IONIC MEDICATION

Iontophoresis or ionization is the attempt to pass certain drugs or chemicals through the skin or mucosa by means of the direct current. If an aqueous solution of a chemical is made, positive and negative ions are liberated and move about in a disorganized way. If a constant current is allowed to flow through this solution, the positive ions gather at the negative pole and the negative ions at the positive pole. For example, in a solution of sodium chloride the sodium ions go to the negative pole and the chlorine ions to the positive pole. Leduc [2] thirty years ago claimed that ionic medication would place any amount of the drug where it was wanted and demonstrated that strychnine sulphate

2. Leduc, Stephane: Electric Ions and Their Use in Medicine, London, Rebman Ltd., 1908.

and potassium cyanide could be passed through a rabbit's skin to kill the animal. Pack and his co-workers verified these results, but the findings do not hold for salts of heavy metals.

Subsequent investigators demonstrated that different ions move at a fixed rate of speed, which increases with the voltage and diminishes with the distance in the electrolyte through which they travel. The speed is roughly in proportion to the atomic weight. Hydrogen is the fastest, and the heavier atoms move more slowly. Therefore, the movement of heavy metals, such as zinc, copper, tin and cadmium, is many times slower than that of hydrogen. The hydrogen ions, being present in great numbers in the body fluids, carry nearly all, if not all, of the current, while the ions of the heavy metals, being much less numerous, probably do not transmit the current at all.

It has also been demonstrated that as soon as the ion of a heavy metal comes in contact with the body it loses its charge and combines with the proteins, first forming zinc oxychloride and then zinc albuminate, and that the effect taking place beyond the mucosa is due to the passage of the current only. Pack and his co-workers [3] found that mercury was not absorbed, and they came to the same conclusion as Turrell [4] that

> . . . the zinc ion attracted from the positive electrode to the negative pole, on arriving at the surface of the body, lags behind, and the current is carried on much faster by the hydrogen ions of the tissues. The zinc ion is thus set free to enter into chemical combustion with the tissue constituents and forms an oxychloride of zinc, which is electrically deposited on the superficial tissues. The process is one of electrodeposition resembling the electroplating of commerce. The skin or mucous membrane thus forms a virtual negative pole.

This theory presupposes that there is a superficial deposit of zinc combined with the proteins to form the zinc albuminate. Friel [5] said that ionization is strictly a local treatment and therefore should be applied to the whole area. Lierle and Sage [6] stated in conclusion that "the possibility of the deposition of metallic zinc in living tissue is remote and open to question."

McMahon [7] showed that when the normal mucosa of the frontal sinus of the dog is ionized with zinc sulphate, marked changes occur in the mucosa. Engorgement of all the capillaries of the subepithelial

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3. Pack, Underhill, Epstein and Kugelmass: Experimental Studies in Electroionic Medication, Am. J. M. Sc. **167**:625 (May) 1924.

4. Turrell, W. J.: Arch. Radiol. & Electrother. **27**:130, 1922.

5. Friel, A. R.: Treatment of Sepsis by Ionization, Practitioner **101**:315 (Dec.) 1918.

6. Lierle, D. M., and Sage, R. A.: Underlying Factors in Zinc Ionization, Ann. Otol., Rhin. & Laryng. **41**:359 (June) 1932.

7. McMahon, Bernard, Jr.: Tr. Am. Laryng. A., 1934, p. 35.

tissue was observed. There were also present a marked extravasation of red blood cells into the edematous subepithelial tissues and certain more or less extensive destructive changes in the epithelium. Hollender and Gorin, in a paper presented before the Illinois State Medical Society in May 1935, stated: "Nasal ionization, histologically, produces an alterative effect characterized by immediate destructive cellular changes with absence of cilia even after resolution has taken place."

Alden,[8] in conclusion, stated: "Clinical observation and microscopical examination of the nasal tissue has thus far shown no evidence of permanent nasal damage following ionization."

My own examination of polyp tissue before and after treatment with the same dose of ionization as that used by McMahon [7] showed some increase in edema to a definite coagulative effect which had fairly well penetrated through the polyp, but no necrosis. It is possible that the difference between McMahon's findings and mine is the difference between normal mucosa and polypoid tissue.

When zinc sulphate is dissolved in water a proportion of the molecules split up into two fragments, namely, an atom of zinc and a group of atoms of the sulphate radical. A solution of a substance in water which undergoes this dissociation into fractions is called an electrolyte. The positive and negative fractions of the electrolyte are called ions. Positive ions are called cations; negative ions are called anions. It has been found that the dissociated molecules in a concentrated solution increase the resistance to the motion of the ions among them; therefore, if one increases the dilution until a point is reached where dissociation is complete, the maximal value of the electrolyte conduction is reached. Therefore, the weaker the solution the better. The strength of zinc sulphate should be from 1 to 2 per cent.

Ionization of the nose has a few advocates, among them Friel,[9] Crabbe [10] and Franklin,[11] in England and Hollender [12] and Warwick [13] in the United States. The latter claimed that much better results are obtained when a small quantity of tin and cadmium is added to the zinc. Because of that claim Alden [8] took up the technic of Warwick, and

8. Alden, A. M.: Laryngoscope **44**:741 (Sept.) 1934.

9. Friel, A. R.: Electric Ionization, ed. 2, Bristol, John Wright & Sons, Ltd., 1922.

10. Crabbe, J. Sandison: Catarrhal Conditions in Nose Treated by Ionization, Brit. J. Phys. Med. **8**:122 (Dec.) 1933.

11. Franklin, P.: M. Press **190**:281 (March 20) 1935.

12. Hollender, A. R.: Ionization as a Prolonged Palliative in Vasomotor Rhinitis, Arch. Otolaryng. **21**:448 (April) 1935.

13. Warwick, H. L.: Laryngoscope **44**:173 (March) 1934.

the favorable results that he has reported have created an interest in this method of treating hay fever and hyperesthetic rhinitis (allergic coryza).

Warwick [13] laid much stress on technical detail, namely: The electrode must be used only once; the resistance must be low; the electrolyte must be a combination of zinc, cadmium and tin with their respective salts, and his special generator is the only one which will give the proper current.

Some criticism was directed at the fact that these formulas were kept secret, but finally the Burdick Company made available mimeographed copies of the formula. These copies stated that the electrode was composed of 97.1 per cent of zinc, 1.9 per cent of tin and 1 per cent of cadmium. An electrode which I asked Professor Muller of the New York University to analyze was found to contain 91.8 per cent of zinc, 3.83 per cent of lead, 2.54 per cent of tin and 1.7 per cent of cadmium; it also contained a trace of bismuth and iron. This led me be believe that the electrode was made from a crude zinc metal. The present electrode contains the following proportion of zinc, tin and cadmium: zinc, 86.0 per cent; tin, 9.48 per cent, and cadmium, 4.34 per cent.

At first the electrolyte was said to contain 9 grains (0.6 Gm.) of zinc sulphate, 0.9 grains (0.06 Gm.) of stannous sulphate, 0.45 grains (0.3 Gm.) of cadmium sulphate and a blue dye. Professor Muller's examination of the contents of the ampule showed undissolved violet dye and zinc and cadmium sulphate and no tin. The present formula has been changed to: zinc sulphate, 8.92 grains (0.58 Gm.); stannic chloride, 1.42 grains (0.09 Gm.), and cadmium chloride, 0.45 grains (0.3 Gm.), to the ounce (30 cc.). Examination of this electrolyte by Dr. W. Grosvenor showed zinc sulphate, 7.193 grains (0.472 Gm.); no tin; cadmium, 0.374 grains (0.023 Gm.), and sodium oxide, 0.058 grains (0.0037 Gm.), to the ounce (30 cc.). This leads one to believe that the formula need not be exact and is subject to modification and improvement. It is better to have the electrode of the same metals as the salts in the electrolyte, as the acid radical will attack the electrode and form more ions of the same sort.

If one remembers that the ions travel with a speed in relation to their atomic weight and that the atomic weight of zinc is 30, that of cadmium 48 and that of tin 50, theoretically it would seem that the ions of zinc would be deposited much faster than those of the other two elements, and considering the much larger proportion of zinc it would appear that the amount of tin and cadmium deposited in the tissues would be little indeed. How much this is an improvement over straight zinc ionization remains to be determined.

TECHNIC

Granting that one has an apparatus to generate galvanic current, whether it is an inexpensive battery set-up or a Burdick machine, it should have meters so that one may know how many ohms, volts and milliamperes one is using.

The Burdick apparatus is especially built for nasal ionization and eliminates error, as much as can be done in a machine. It has ohm and milliampere meters, terminals which plug in so that one cannot make a mistake as to poles and a clock which times the length of flow of current and also turns off the current at the end of the treatment, so that there will be no shock.

According to Warwick, the nose should be anesthetized and carefully packed with cotton strips saturated with the electrolyte; then the metal electrode, which has been wrapped with cotton, should be introduced in the center and more cotton packed around it. The arm cuff, separated from the skin by a pad saturated with saline solution, is placed on the forearm after the skin has been cleaned with a grease solvent. The negative pole is connected to the arm cuff, and the positive pole, to the electrode in the nose. The ohm meter reading, to be satisfactory, should be between 2,000 and 3,000. If it is higher, Warwick advised repacking the nose, but before this is done an attempt should be made to pass a couple of milliamperes through the circuit and then the meter should be read again. Usually at the second reading the resistance of the skin is diminished and the ohm reading is lower. According to Ohm's law, amperage equals voltage divided by ohmage; two factors being known, it is easy to obtain the third. For example, if there are 3,000 ohms and 10 milliamperes, multiplying the number of ohms by the number of milliamperes gives 30, or the number of volts. If there were 6,000 ohms and 3,000 milliamperes the voltage would equal 60; hence it is well to have the resistance as low as it can be obtained by good contacts at the two poles. Warwick advises a dose of 100 milliampere minutes, that is 10 milliamperes for ten minutes.

This dose is arbitrary, as it depends on the surface area of the nose as well as on the time and current. For example, if the area of one nose was 40 sq. cm. and the dose 100 milliampere minutes, for an area of 80 sq. cm. the dose would have to be 200 milliampere minutes to produce the same electro-ionic treatment.

The current is gradually turned on until it reaches the milliamperage desired. As soon as the current begins to flow at the required strength, the patient notes a metallic taste and there is an increased flow of secretion from the eyes, nose and mouth.

After the current has flowed for the required length of time, it is gradually turned off and the nasal packs are removed. The nasal membrane is found to be contracted and coated with a grayish-white deposit.

After receiving the treatment the patient complains of a headache, which becomes severe and lasts for several hours, requiring a sedative. The nose becomes obstructed, and the next day the mucosa is covered with a jelly-like fibrin which persists for from three to five days, during which time there is almost complete nasal obstruction. The fibrin should be allowed to come off spontaneously. The membrane will remain red for several days.

I have made some modifications in the technic, abandoning the Burdick cuff because it was hard to obtain good contact and the patients complained of disagreeable sensations in the arm when it was used; I am now using the old method employing flexible sheet metal heavily padded with cotton (½ inch [1.27 cm.] thick when wet), saturated with physiologic solution of sodium chloride, as the large negative electrode. I administer 1/150 grain (0.4 mg.) of atropine sulphate before the treatment in order to reduce the unpleasant salivation, and I am now experimenting with the method of flooding the nose with the electrolyte instead of inserting a packing, which was uncomfortable and in many cases on account of anatomic irregularities could not be done satisfactorily.

Mr. Anderson, president of the Burdick company, gave me a U-shaped glass tube for this purpose. The tube was devised by J. Sandison Crabbe,[10] of Birmingham, England, in 1920. Gale [14] devised a similar tube which is used in the same way. I have used a simpler and less awkward tube which is made with a nasal tip of hard rubber, connected with rubber tubing to a small glass tube just large enough to admit the electrode. Near the end of the glass tube a piece of tape is tied. At the other end of the tape is a 2 ounce (62 Gm.) lead weight. The rubber tubing is 3 inches (7.62 cm.) and the glass tubing 4½ inches (11.4 cm.) long.

The patient bends forward until the face is horizontal with the floor; the nasal tip is held tightly in the naris by the patient, and the glass tube is brought up vertically beside the patient's ear and held there by the tape, which is passed across the back of the head and held in place by the weight. By this method the nose is flooded until the electrolyte runs out of the opposite naris, and the electrode is inserted into the electrolyte in the glass tube. There is much less discomfort; in fact this method is a pleasure to the patient as compared to packing, and it is superior to packing because all mucosal surfaces are in contact with the electrolyte, a thing which is impossible by the packing method. All good things have a drawback; in this case the flaw is that the olfactory cleft is affected, whereas in packing it is not, and the result is an anosmia which lasts for some weeks. This defect must be overcome.

14. Gale, C. K.: Laryngoscope **45**:110 (Feb.) 1935.

RESULTS

Warwick reported forty cases in which ionization was used over a period of more than a year, with practically 100 per cent successful results, principally for hay fever; a few cases of hyperesthetic rhinitis and three cases of asthma with hay fever are included in the series. Many of the patients have had no recurrence for from one to six years —a wonderful record.

Alden [8] treated nineteen patients in 1933 for autumnal fever during the attack, and all were relieved. Nine had no recurrence the second

Results of Treatment with Ionization

Percentage of Improvement	Hay Fever (521 Cases)	Number of Cases	Percentage
95-100		302	58.0
85- 90		44	8.4
75- 80		43	8.2
60- 70		20	3.8
40- 50		46	8.6
Less than 30		8	1.5
No relief		58	11.1
	Asthma (194 Cases)		
95-100		76	39.0
80- 90		8	4.1
70- 80		17	8.7
60- 70		9	4.6
50- 60		25	12.8
40 and under		5	2.5
No relief		54	27.7
	Hyperesthetic Rhinitis (111 Cases)		
95-100		47	42.3
80- 90		8	7.2
70- 80		15	13.5
60- 70		3	2.7
50- 60		10	9.0
Less than 40		8	7.2
No relief		20	18.0
	Allergic Conjunctivitis (6 Cases)		
Complete relief	4	No relief	2
	Urticaria (22 Cases)		
Complete relief	3	No relief	17
Moderate relief	2		
	Migraine (2 Cases)		
Moderate relief	1	Slightly relieved	1
	Allergic Dermatitis (Not Urticaria) (2 Cases)		
	No relief		

year; two had symptoms similar to those they had in 1933, and eight had such mild symptoms that he did not think it necessary to repeat the treatment. In 1934, forty-one patients were treated by ionization before the appearance of symptoms; 50 per cent were protected.

The Burdick Company has compiled the results obtained by many physicians who used the method of Warwick during 1934 and, in a few cases, in 1933. The results are given in the table.

Hollender,[12] who used zinc sulphate, reported similar results for hyperesthetic rhinitis. Franklin [10] reported that 50 per cent of patients with hay fever and 60 per cent of patients with hyperesthetic rhinitis were free from symptoms. He used a 1 per cent solution of zinc

sulphate and gave three treatments, using from 3 to 5 milliamperes for from twelve to twenty minutes.

REPORT OF CASES

CASE 1.—A woman, aged 27, had nasal dripping and sneezing which had become so bad that she could not work. She was thoroughly tested by two expert allergists, but no results were obtained. The mucosa was pale and swollen and showed a profuse serous discharge. The patient received treatment with ionization over a year ago; all symptoms are now relieved, although the mucosa is still pale. She has since discovered three things which caused her symptoms: pineapple, peas and a packed food called "Spaghetti Dinner."

CASE 2.—A man, aged 26, for 6 years had fever and hay fever in the autumn, and for the rest of the year he suffered with sneezing and nasal discharge daily up to 9:30 a. m. He received injections of protein with no result. Treatment with ionization was administered in June 1934, and immediately after that he went on a 4,000 mile motor trip through the Middle West. He has had no allergic symptoms, but he now has coryza due to pollen of trees.

CASE 3.—In another case, that of a woman aged 20, the mucosa was merely wet with electrolyte. Nasal obstruction, watery discharge, sneezing and a burning sensation in the nose and eyes had been present for two years. Many eosinophils were found in the discharge, and 10 per cent eosinophils were present in the blood smears. This was one of the first cases in which flooding was used instead of packing. The technic was poor; most of the electrolyte leaked out, and there was none in the nose when the tube was removed. The solution used by Warwick was used on one side and solution of zinc sulphate 2 per cent on the other. The reaction was the same on the two sides. Eight weeks later the patient suffered a relapse. In this case the mucosa was merely wet, not covered, with the electrolyte.

I am not ready to tabulate my results, as in some cases I have used the method described by Warwick, in others I have applied that method on one side and another technic on the other side, and in others I have used a still different method.

In cases of hay fever in which treatment by ionization was used during the attack the percentage of good results has been high; in cases of hyperesthetic rhinitis over 70 per cent of the patients have become symptom-free.

CONCLUSION

1. The nasal mucosa shows microscopic changes immediately after ionization.

2. Zinc ions do not enter the tissues in any appreciable amount.

3. There is a marked clinical reaction of the nasal mucosa lasting about one week.

4. Symptoms of hay fever disappear immediately after ionization in nearly all cases.

5. Symptoms of hyperesthetic rhinitis are relieved in the majority of cases.

39 East Fiftieth Street.

SINUSITIS ALLERGY AND THE COMMON COLD

A CONCEPTION OF THEIR RELATIONSHIP

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Inflammatory disease of the nose and sinuses is noninfectious and infectious in origin.

Wittmaack has shown that noninfectious irritants change the character of the young aural mucosa and make it more susceptible to chronic infection. His outstanding contribution to pathology has failed to recognize allergy, which is perhaps the most important irritative influence.

Edema is the chief characteristic of allergic inflammation. By its action the fibers of the submucosa are separated and floated apart. Immediate swelling of the tissue results, more marked in infantile mucosa, which still retains the embryonic reticular arrangement of its fibers. The immediate swelling of the tissues may be considerable. However, it has been exaggerated to explain the evanescent shadows on the x-ray film. It is obviously impossible for normal mucosa, which is as thin as cigaret paper, to become 1 or 2 cc. thick without the time element essential for hypertrophy of tissue. Some other explanation must be given for this type of x-ray evidence. Either the tissue is diseased and abnormally thick before the acute swelling occurs or thickened mucosa is simulated. Inspissated mucus pads will do this, as has been demonstrated by the staff of the x-ray department of Stanford University Hospital. They have noted a reduction in the thickness of the shadow immediately after blowing the nose.

No permanent changes in the tissues have been ascribed to acute allergic phenomena. While this may be essentially correct for a single attack, recurrent involvement must eventually cause permanent morbid alterations. Stimulation of submucosal fibrous tissue characterizes inflammation. Such attacks early in life exaggerate and perpetuate the reticular character of the submucosal fibrous tissue. Thus is built, by noninfectious agencies, a type of mucosa favorable to bacterial growth and prone to chronic involvement. This allergically altered mucosa will be discussed in connection with acute and chronic sinusitis.

The discharge from an allergically altered mucosa is clear in the absence of infection. The few cells present may be eosinophils. Purulent or mucopurulent discharge during sinusitis is only the result of the chemotactic activity of bacteria and is thus an evidence of infection, and infection is always more than allergy.

Read at the Fifty-Seventh Annual Congress of the American Laryngological Association, May 31, 1935.

Infectious inflammatory processes may be divided into acute and chronic processes.

ACUTE INFECTIOUS RHINOSINUSITIS

Acute infectious rhinosinusitis or the common cold is the most important challenge in medicine. The ravages of its complications pale all other scourges including cancer into insignificance. Most opinion is divided as to its cause between the common pus-forming germs and a filtrable virus. It seems to me possible to combine these two apparently divergent opinions and find the true answer to the problem.

The common cold, in my opinion, is always due to the pus-forming bacteria, and they are always activated by a filtrable virus.

The objection to their etiologic importance has been raised that (1) it is frequently impossible to communicate the disease experimentally by bacterial transference, and (2) it is possible to pass the disease by transference of nasal discharge from which all bacteria have been filtered.

The first objection is easily satisfied because it is impossible to determine for experimental purposes those who are not at the time immune to colds. Some rare persons have practically a permanent immunity. Most persons are granted an immunity of from six months to a year by an acute cold. During the immune period they will not "take cold." One or two colds a year, in spite of almost universal exposure, is the recognized average. While there may be some variation from this affirmation, the fact is that so-called frequent or recurrent colds are not reinfections but exacerbations of chronic sinusitis. Chronic sinusitis is so frequent that the confusion in the minds of many is understood.

The second objection may also be met by a consideration of bacterial characteristics. The pus-forming germs are almost universal in the upper air passages. They lead for the time a saprophytic existence. An outside agency is required to raise their virulence to the point where they will attack the tissues and give rise to the clinical picture known as a common cold. Their low virulence has been determined and has been repeatedly increased by animal inoculation. Increase in virulence is understood by the immunologist and is associated with the products of bacterial activity in the tissues. These substances, variously described as aggressins, etc., have antiphagocytic actions and have power to reduce body resistance and increase bacterial virulence. They activate the fluids included in the name "filtrable virus" by which colds have been experimentally transmitted. This so-called virus not only increases the virulence of bacteria in the tissues of the host but, I believe, is transmitted with the nasal secretion to activate the temporarily saprophytic germs of similar type in the nose of the host and also in that of another to

whom it may be communicated. Under its stimulation their virulence is increased to the point where they attack the tissues which have carried them as surface saprophytes.

There must therefore be a never ending source of this virus, or colds would vanish from the earth. Just as are malaria, typhoid, etc., so is the common cold dependent on some ever replenished reservoir. That focus must be a place where the pus-forming germs are *in the tissues.*

A satisfactory ideal for such a reservoir is furnished by chronic sinusitis which, I believe, is the chief source, the endemic reservoir, for the perpetuation of the common cold.

I do not mean that one must have chronic sinusitis to contract a cold, but that chronic sinusitis must exist in some one for the pus germs lying in the chronically diseased mucosa to produce the virus capable of activating the same bacteria in others.

To recapitulate, I believe that colds are perpetuated only in the following manner: The common pus-forming germs are the direct cause. They lie in the mucosa of the chronically diseased sinus. The lapse of immunity, associated with the complicated factors that reduce resistance, allows them to become active in the tissues. This activity is associated with the production of a virus that not only promotes the virulence of the sinus infection but, discharged as a secretion from the sinus, activates the same type of bacteria lying in a saprophytic state on the mucous membranes of that same person. The result is the common cold engrafted on a chronic sinusitis.

The virus secreted as nasal discharge will activate the same type of pus germs lying in a saprophytic state in the nose and throat of another person and cause an acute cold. Thus the vicious circle of the common cold appears never ending until such time as the endemic reservoir in the chronic sinus may be rendered innocuous or removed.

This conception of the importance of chronic sinusitis as the reservoir for the activation of the common pus germs may even be carried to the probable theoretical absurdity that without it there would be few pus germs. It is recognized that operating in the farm house, as pioneer western doctors did, reduced infection to a minimum.

The morbid changes that characterize a common cold depend on the histologic structure of the mucosa. One can distinguish three types of mucous membrane. Each is subject to infection and determines the character of the inflammatory process.

1. Normal Adult Mucosa. It is as thin as tissue paper—0.1 mm. The fibrous layer is compact in arrangement. It contains few blood vessels and glands. It acts as a periosteum and also supports the columnar ciliated epithelium resting on an ill defined basement membrane. There are few goblet cells.

The normal, active cilia, the layer of protective mucus and the inherent immunity ward off infection. When these resistant barriers are penetrated there is little in the tissue itself to impede the entrance of disease. However, the inflammatory process that results is of short duration and mild because there is little food for activity in such bloodless, glandless tissues. The process quickly burns itself out for lack of fuel. The normal tissue reacts properly and intensely to the infection. Exudation is unimpaired. The products of infection and the infectious agents themselves are soon carried away.

Whatever may be the importance of virus in inciting bacteria or tissues, the bacteria themselves at first induce an activity comparable to that induced by the noninfective irritants described. A clear, watery discharge, the ultimate effect of the noninfectious irritants, is immediately secreted. The bacteria, however, soon assert their inherent chemotactic activity. This is demonstrated by cellular infiltration, predominantly polymorphonuclear, and is reflected in the discharge by yellowish coloring and thickened consistency. There is comparatively little mucus because of the scarcity of glands and goblet cells. As the defense forces gain mastery the bacteria lose their chemotactic activity, act only as irritants, and allow the discharge again to become clear. When recovery takes place the discharge soon disappears except for the normal layer of cohesive mucus of which one is never conscious.

Each inflammatory attack, however mild, stimulates an increase in the fibrous tissue. In normal mucosa it is left more dense by such an acute attack of short duration. This reduces the food value for subsequent infection. As a result each succeeding attack of common cold that entirely heals promotes greater resistance to disease. Normal persons have fewer and milder acute colds as age advances unless they acquire chronic sinusitis. Because of the normally functioning defense chronic sinusitis rarely develops in this type of mucosa. It may do so on occasion. If so, a characteristic type of sinusitis results—purulent sinusitis. This statement will be expanded under the heading chronic sinusitis.

2. Altered Mucosa. Such mucosa is thicker than normal because of the reticular arrangement of the fibrous tissue. The tissue is essentially edematous. It contains more mediums available for infection. There is clinical evidence to make one believe that it becomes diseased more readily. Abnormality of structure and lowered resistance are concomitant. The process at once becomes more vicious than with a normal mucosa. The bacterial action is at first comparable to that of the noninfective irritants. Like them, the bacteria at first cause an exudation of clear, watery serum. Soon, however, they exert chemotactic influence and cause a more or less dense cellular infiltration.

Polymorphonuclear leukocytes predominate in proportion to the severity of the process. Both serum and cells leave the tissues and accumulate in the sinus as discharge.

While the battle may be protracted, the body defenses usually modify the activity in a few days. The call for leukocytes lessens. They decrease in numbers. The discharge becomes more viscid. It consequently moves sluggishly and drains inadequately. Its retention acts to stimulate morbidity and impede recovery. This thick viscid discharge adherent to the sinus wall may simulate in the x-ray film a thickening of the mucous membrane.

Eventually there may be complete recovery from the acute attack even in the face of an altered mucosa. The tendency toward chronicity in fact depends, to a large extent, on the degree of morbid change. If recovery takes place all discharge ceases. Each acute attack adds to the reticular edematous fibrosis. The tissues then gain vulnerability and are prone to chronic sinusitis eventually. This is in contrast to the effect of acute healed inflammation in a normal mucosa which tends to increase the compact fibrosis and make it more resistant.

When recovery does not take place, chronic hyperplastic sinusitis is established. This is the most common type of chronic sinusitis because of the prevalence of an underlying altered mucosa.

3. Diseased Mucosa. This is always present in chronic sinusitis. It is chronically infected. It is subject to frequent exacerbations of its condition which are not reinfections. The exacerbation is often confused with the common cold. The diseased mucosa also may become reinfected, however. A common cold is then engrafted on a chronic sinusitis.

CHRONIC INFECTIOUS RHINOSINUSITIS

Two distinct types of this disease have long been recognized because of their clinical dissimilarity. No explanation for the variation has been given. Hajek[1] has said: "In cases of long standing empyema rhinoscopic examination reveals the objective findings of an atrophic rhinitis. . . . We have never clearly understood why atrophy has followed disease of the accessory sinuses." I believe that the atrophic character of chronic sinusitis depends on whether it has been engrafted on a normal mucosa. It never occurs in allergically altered mucosa.

Chronic Purulent Rhinosinusitis.—This disease is rare as compared with chronic hyperplastic sinusitis. It is usually the result of a common cold or an acute infection in a person with a normal mucosa. Such mucous membrane is thin and poor in glands and blood supply. The fibrous layer is compact and ill fitted to encourage chronic infec-

1. Hajek: Nasal Accessory Sinuses, St. Louis, C. V. Mosby Company, 1926, p. 561.

tion. Its density may even have been increased by previous healed acute infection. Unusual factors embracing anatomy, immunity and virulence must conspire to accomplish its chronic infection.

Owing to lack of considerable edema the mucosa remains comparatively thin. The irritated and engorged vessels shine through to give a characteristic redness to the nasal mucosa, which color often extends along the respiratory tract even into the bronchi. The same lack of protective moisture of the tissue, edema, allows the epithelium to feel the full brunt of the inflammation, and it is altered in atrophic fashion. Cilia are lost, and the columnar cells may be changed by metaplasia into the protective pavement variety. The mucosa tends then to display a smooth, glazed surface. This is particularly true in the pharynx and nasopharynx and gives rise to distressing irritation manifested by persistent and spasmodic coughing.

As there are few glands and goblet cells, lack of mucus in the discharge is characteristic of this type of sinusitis. In the height of an acute exacerbation the discharge is frank disintegrated pus. The microscope then shows it to contain mostly polymorphonuclear leukocytes. It does not coagulate because this property of the serum is destroyed by bacteria. In latent periods of the disease the discharge may be almost absent, watery and clear. It can be seen bathing the mucosa as a transparent, or sometimes milky, film. It is apt to be of this character in the later stages of the disease when atrophy is manifest, and this is one reason why its etiologic importance in atrophic rhinitis has been rejected. Lacking mucus, which retains moisture, the water is soon lost from this type of discharge as it accumulates in the nose, nasopharynx, pharynx, larynx, trachea, etc. Consequently crusts form from the solid matter contained. These crusts through mechanical pressure and consequent irritation increase the surface atrophy. The nasal mucosa becomes more thin and glazed and consequently bleeds easily. The crusts may, in the exaggerated stage of the disease, accumulate and exhale a characteristic odor. They are particularly adherent in the nasopharynx where air currents rapidly dry and cause them to adhere. Their presence is so frequent and their source so ill understood that they are still often described as a disease entity, namely, as nasopharyngitis.

The underlying bone may show mild to extreme atrophic changes, depending on the chronicity and severity of the process.

Thus only, in my opinion, can one reasonably explain atrophic rhinitis. It can be prevented by curing the purulent sinusitis. I have satisfied myself as to this by stopping its obviously early stages. Purulent sinusitis is not influenced by chilling and unfavorable climatic conditions in the way or to the extent that the hyperplastic type is. In a dry climate crusting is an important characteristic and may be increased by desiccation to the discomfort of the patient.

Chronic Hyperplastic Rhinosinusitis.—This is the usual form of chronic sinusitis. It is very common. It differs from chronic purulent sinusitis in that it does not occur in those with a normal adult mucosa. It is the result usually of a common cold on an altered mucosa. It may present itself in infancy while the mucosa still retains embryonic characteristics and is delicate, reticular and well nourished or at any period in life in mucosa that has been chronically altered by noninfective inflammation, particularly allergy.

This type of sinusitis is essentially edematous. Goblet cells secreting abundant mucus replace the columnar ciliated cells. In extreme cases the cells are confused with the cap of viscid mucus covering them. The basement membrane is thickened and the yellow elastic layer distended and ruptured to allow the formation of polypoid masses. The submucosa is hyperplastic, edematous, more or less infiltrated and tremendously thickened. The edema protects the underlying bone so that it is rarely involved. Therefore this form of sinusitis never causes atrophic rhinitis.

The etiologic allergic influence, if present, may persist as a contributing factor that acts with infection to exaggerate and perpetuate the disease.

Allergy alone does not suffice to cause chronic sinusitis. It acts as a mechanical irritant without considerable chemotactic activity. The discharge that it produces without the aid of infection contains, therefore, few leukocytes. It is clear and watery in consequence.

Infection is always more than allergy. It exerts chemotactic properties during periods of activity. It is characterized in chronic sinusitis by a leukocytosis that thickens and colors the discharge. This distinction is affirmed by the microscope, an important diagnostic aid that may serve to lead the clinician upward even from the trachea itself, through the pharynx, nasopharynx and nose, eventually to the source of the cells in the defective sinus, even as the prospector pans his trace of gold from the gravel of the creek bed successively upward to the mother lode. This is made possible because pus cells are wanton to these parts and their source so frequently a diseased sinus. The infectious process is established mostly in the submucosa, where it lies fairly dormant except during vasomotor disturbances and acute bacterial exacerbations.

With the passing of the acute infection, whether an initial attack or a reinfection, the morbid activity quiets down, controlled by the forces of bodily resistance. The bacteria, to a large extent, lose their chemotactic activity. They act again as irritants, evoking a more or less constant discharge that is almost acellular. The polymorphonuclear leukocytes, evidence of virulent bacterial activity, are replaced by

mononuclears, which are significant of chronic infection. Cells may be so scarce in the sinus that a cytologic aspiration study of the sinus content is required to demonstrate them and show that the disease is not "cured," as is frequently presumed. The tissues now carry an immunity granted by the last acute infection. Ordinarily no reinfection with the typical picture of a fulminating common cold takes place again for six months or a year. Later in life even a much longer period between acute attacks supervenes.

The mucosa in chronic hyperplastic sinusitis while still immune to acute bacterial attack is subject to morbid changes that lead to disturbances closely simulating a reinfection. These processes are usually erroneously referred to as colds. One is said to have repeated or frequent colds or one cold after another. This is not true if one assumes that a cold is an acute self-limited disease. They are not reinfections and therefore not true colds. They are almost invariably caused by chilling of the body and may be considered provocatively vasomotor. These exacerbations repeat themselves frequently even in warm weather, particularly where the humidity is low. The response occurs so quickly that it is a cause of wonderment. Chilling of the body, cold, wet feet or even hands cause a blanching of the surfaces including the upper respiratory tract in response to the phenomenon of heat conservation. An immediate reduction in the defense factors allows the latent infection to reassert its irritative activity. A resultant increased watery discharge follows immediately. If now the body is warmed the blood again with startling rapidity causes a cessation of activity and the discharge resumes its chronic status. If, however, chilling is extreme and prolonged the chemotactic powers of the bacteria assert themselves and leukocytes appear in the secretion in great numbers. The discharge assumes a yellowish character, more than ever simulating a reinfection. However, a return of body warmth again limits the process, and what the patient thought was a beginning cold clears up inexplicably, and the chronic picture again presents. These vasomotor attacks may repeat themselves frequently and have given rise to the opinion that the common cold may occur repeatedly.

When immunity does expire these chronically hyperplastic sinuses are subject to reinfection from within and without. The acute process is usually ushered in by body chilling. The altered mucosa, however, grows more resistant to acute attack with the years, perhaps because of the greater thickness of the basement membrane that shows almost invariably histologically. In this type of sinusitis there are fewer true colds as age advances.

In this article I have had the temerity to state that chronic sinusitis is the chief endemic focus from which develops the infection called the common cold.

There is much authoritative material to support this opinion. Very significant is experience in the polar regions. The natives are free from colds except when the colds are brought to them by persons from the outside. They have contracted epidemic colds on meeting a crew of explorers who up to that time had themselves for months been free from colds. After the colds were well started among the natives the crew of explorers in turn developed the same epidemic colds.

The explanation of this phenomenon seems obvious: A portion of the crew had, according to statistical incidence, chronic sinusitis. In those affected the germs occupied the tissues. The product of their activity in those tissues passed via the nasal discharge freely among them. The low temperature and their habituation to civilization's bacterial flora prevented their taking colds from one another. The Eskimos, however, were unused to the flora and fell an easy prey to the germs and virus from the outside. These were the products of the action of bacteria in the tissues of the crew as distinguished from the bacteria lying in the nose and mouth in a saprophytic state. It is this action of germs in the tissues that gives them virulence as shown by laboratory work and is the important factor in the transmission of colds.

The activity of the germ in the tissues of the nonimmune Eskimos quickly established a virulence—so frequently demonstrated in clinical experimentation—that the crew themselves could not resist. They then fell victims to their own rejuvenated germs.

Stanford University Hospital.

DISCUSSION

Dr. Lee Wallace Dean, St. Louis: I want to bring into the discussion the question as to whether metabolic disturbances do not produce the identical picture which Dr. Sewall has presented.

One sees adults and older children whose disorders are diagnosed as allergic rhinitis who present the usual blocking of the nose by edematous mucous membrane. On purely nutritional treatment, excluding every other form of therapy and paying no attention to the allergens, I have seen these patients improve. I think that nutritional disturbance plays just as important a part in the etiology of the common cold as does the allergic disturbance; further, while I know nothing about ionization, I think that Dr. Sewall came closer than any one else to suggesting what should be the indication for ionization. If one gets results from this form of treatment those results depend on the tissue changes in the nose. I am not recommending ionization in any sense, but if one is to get good results it will have to be on the basis of correcting certain tissue changes in the nose, not on the presence of substances in the blood stream or on the basis of the sensitivity or insensitivity of the nasal mucous membrane.

Dr. E. Ross Faulkner, New York: I have regarded chronic sinusitis as a menace to public health. The patients with that condition probably infect the immediate neighborhoods where they live.

Unquestionably it is a family disease. Any one in practice for years, who has seen many of these cases, will observe this phenomenon: A young man or a young woman with chronic sinusitis gets married and infects the partner. In the baby

at the age of 4 or 5 months an acute illness develops and the pediatrician does not know anything about it. The temperature may be 105 F., and there is a lot of guessing. The baby is having its initial sinusitis or initial tonsillitis. I have seen this condition go through families for three or four generations, and I have treated the left antrum in three generations in one family.

While I believe in Dr. Rosenau's theory of specific localization, Dr. Sewall's explanation of the local character of the membrane is possibly more logical. The subjects whom I mentioned had identical anatomy—the grandmother, the mother and the child.

I believe we shall all know more about this when the specific quality of an infection is established.

I have no doubt of the truth of what Dr. Sewall says, that the individual condition of the mucous membrane probably is another factor.

Dr. Roy Nelson, Oakland, Calif.: With regard to chronic sinusitis being the reservoir—the endemic reservoir—from which the common cold is spread, it is difficult for me to conceive how a minute droplet of secretion from the nose, an inanimate droplet which can therefore act only by physical or biochemical means, could so upset the defense mechanism of the body as to allow organisms previously there but saprophytic to penetrate and set up a general acute infection.

Dr. Sewall referred several times to the fuel value of the tissues, stating that the normal tissue had less and the disease tissue more; that statement to me was not one easily understood scientifically. I should phrase the interpretation in this way: The normal tissue has better blood supply; a reticular tissue has less blood supply in proportion to its volume than the normal; a myxomatous tissue has still less, and an edematous tissue has a very small supply of blood, which accounts for the grayness and pallor seen in the edematous nasal mucous membrane, and the edema and like conditions, increasing tissue tension, further reduce the blood supply, thereby establishing a vicious circle. The difference in blood supply throughout the body is a strong factor in resistance to infection.

CAUSES OF FAULTY INTERPRETATION OF ROENTGENOGRAMS OF THE SINUSES

F. M. LAW, M.D.
NEW YORK

Roentgen examination is not an Aladdin's lamp but an exact science, mathematically governed. Unfortunately the mathematics are complicated by the human equation, and this discussion is an attempt to remove some of the variables from this equation.

The errors which I shall describe are those which I have found to be made most commonly by the surgeon who reads his own films without consulting with the roentgenologist and will serve to emphasize my request for a more personal touch between the surgeon and the roentgenologist.

It would be wise for the surgeon to read the report of the roentgenologist and then examine the films and form his own opinion. If there is a discrepancy, the roentgenologist should be consulted, and possibly he can explain the reason that the two opinions do not agree. There are factors in the technic, the history and the clinical findings which may influence the interpretation, and unless the interpreter is in possession of these facts he cannot render a helpful decision. A roentgen examination is really a consultation, and the roentgenologist is entitled to all the help he can get.

Before a report can be given it is necessary that the films be as nearly perfect as it is possible to make them and of sufficient number to reveal the sinuses in all diameters. I am especially partial to stereoscopic films, and those surgeons who possess stereoscopic views find the added information of particular value. The third dimension improves the quality of the films and gives a more comprehensive view of the relationship of the structures, as well as correction of a faulty angle of the technic In films made with the patient in the verticomental position for the sphenoid sinuses a pair made stereoscopically is absolutely essential. I do not advise stereoscopic films for patients seen in a clinic, as it is too expensive, and it is easy to have the patient return for another examination if the first films are not adequate in a particular case. In private practice, however, the examination must be complete on the first visit.

Read before the Section of Laryngology, Otology and Rhinology at the Eighty-Sixth Annual Session of the American Medical Association, Atlantic City, N. J., June 13, 1935.

The films must be made with the strictest attention to every detail in the technic. Sometimes a very slight change in the correct angle will falsify the diagnosis, and the slightest movement will ruin the value of a film.

The modern tendency is toward the use of the Potter-Bucky diaphragm. I do not approve of its use in roentgen examination of the sinuses or mastoid processes, except for determination of the anatomy. The contrast is too great. The reason for its use lies at the feet of the surgeon. He demands a film of beautiful contrast, in other words, a pretty picture. The Potter-Bucky diaphragm gives this, but in doing so the marked contrast is likely to mask a mild inflammatory process. Then, too, this diaphragm causes a distortion of the fine bony lines, making it difficult to distinguish the pathologic changes.

Faulty time of exposure will alter the appearance. Too thin a film will produce the appearance of a greater amount of opacity in a sinus, and too great an exposure will produce the appearance of a less involved sinus. One must consider the gross density of the film before analyzing the condition of the various sinuses.

A slight tilting of the head from the perpendicular will change the appearance of the ethmoid sinuses and the antrums unless a stereoscopic pair of films is used in the viewing box.

Films of the sinuses made with the patient in the upright position will show a fluid level but will mask any granulations or polyps on the floor of the antrums.

With the patient in the Waters position the film does not show the posterior portion of the floors of the antrums as they are projected downward behind the image of the teeth.

The posterior fossa and occipital bone are sometimes thicker and denser on one side, and this may give the appearance of involvement in one antrum on films made at the standard postero-anterior angle. A stereoscopic pair of films will show the dense bone well posterior to the antrum and will remove the aforementioned error.

Stereoscopic verticomental films are necessary to show the shape and size of the sphenoid sinuses and the presence of anomalous ethmoid cells. Sometimes no image of the sphenoid septum is seen, and this is due to an inclination of the septum to one side of the perpendicular, causing the roentgen rays to pass through a plane surface rather than at a perpendicular angle. A postero-anterior view of the sphenoid sinuses may reveal this condition. Many times the wings of the sphenoid bones are mistaken for the anterior walls of the sphenoid sinuses, as viewed on a film made from the lateral view.

Sometimes a small frontal sinus will be so severely involved that the outline is lost. A pair of films taken from the oblique angle and with the patient in the Waters position will reveal the outline clearly.

The sinuses may have drained before the roentgen examination is made and thus may give the appearance of clear sinuses, so that a diagnosis is preferably based on the character of the walls of the cells in conjunction with the degree of opacity of the sinuses.

The walls of a normal sinus are sharply and clearly defined, with a fair degree of consistency or thickness, and any inflammatory process will alter this clear appearance.

Acute or subacute sinusitis is manifested as a fuzzy thickness and blur to the outlines.

Chronic sinusitis will show thickened or markedly thinned walls, with a clearly defined outline.

Numerous anomalies in anatomy are revealed by the film and should be noted on the report by the roentgenologist. A knowledge of these anomalies may assist greatly if operation is decided on.

The character of the anterior wall of the frontal sinuses governs the appearance of a large frontal sinus. If the wall is thin and regular in density, any change in the degree of opacity is due to granulations or fluid. If the anterior wall is irregular in thickness, a mottled appearance, simulating granulations, may be seen.

ABSTRACT OF DISCUSSION

Dr. W. E. Chamberlain, Philadelphia: For the interpretation of roentgenograms of the sinuses it is essential to know the anatomy, physiology and pathology of the sinuses. Who knows that better than the well informed rhinologist? The roentgenologist is trying to keep up with the clinicians in all the other specialties and is hardly to be expected to know quite as much about the accessory nasal sinuses as the rhinologist. That places him at a disadvantage. He has one or two possible advantages that may make him worthy of inclusion in the circle of consultants with whom the rhinologist works in cases of sinus disease.

The rhinologist inevitably becomes interested in interpreting his own roentgenograms. It is right that he should, and with some experience and a little knowledge of the fundamental physics and mathematics that Dr. Law has pointed out he should be able to do a very good job of this.

Why should the rhinologist continue to treat the roentgenologist as a consultant in every sense of the word rather than as a technician? There are three possible reasons: In the first place, if the roentgenologist is treated as a technician, his technic will suffer, for he will lose interest and will not be so critical. He may even fail to take a sufficient number of views, because a certain responsibility which should be shared between himself and the rhinologist will not rest on his shoulders. The converse of this is that if he is treated as a consultant he will feel his responsibility, add to his examinations and be inclined to work with the rhinologist for the best interest of the latter and for the best interest of the patient. Another reason for treating the roentgenologist as a consultant is the fact that he views the roentgenograms more objectively than the rhinologist does. However much of the clinical side he knows, he still views them objectively, for he comes across instances in which a prejudice due to clinical knowledge has caused trouble. Therefore, he is inclined to view the roentgenograms very objectively at the start and

then turn to the clinician for accessory aid and for a review of the roentgen interpretation in the light of the clinical observations.

The third reason for treating the roentgenologist as a consultant is that two heads are better than one.

I cannot add anything to Dr. Law's technical advice or interpretation. The only thing I can do is to emphasize his plea that the roentgenologist be given a chance to remain interested and a chance to advance his knowledge of the anatomy, physiology and pathology of the accessory nasal sinuses by standing at the elbow of the rhinologist and having the rhinologist stand at his, so that the two together may improve their technic and ability to interpret the roentgenograms.

Dr. S. R. Skillern Jr., Philadelphia: Dr. Law, to the best of my knowledge, is the only otorhinoroentgenologist in America. His excellent advice should help the otolaryngologists to avoid many of their former errors in interpreting the roentgenograms of the sinuses.

Dr. Law speaks of the human equation in the interpretation of the roentgenograms, and advises one to read the roentgen report, then examine the roentgenograms and form one's own opinion. I agree with him in everything but the order of his routine. I think that the surgeon should first interpret the roentgenograms, compare his interpretations with his clinical observations and then read the roentgenologist's report. If all three agree, well and good. If not, a consultation should be held with the roentgenologist, giving him all the benefits of the history and physical observations, which may influence his second interpretation of the films.

I have always avoided sending the patient directly to the roentgenologist after an examination, as I do not believe that the roentgenograms can show the true condition after the use of astringents, irrigation or suction; therefore, I have the roentgenograms made just prior to my second examination. One can then chart the condition of the nose at the time that the roentgenograms are taken, which gives a foresight of them. The observations should always be recorded, as certain areas may appear normal on the roentgenogram.

I agree with Dr. Law that the greatest number of errors are caused by the surgeon's demand for roentgenograms showing beautiful contrast. Underexposure is preferable to overexposure, and a pair of stereoroentgenograms will always give a greater knowledge of the true condition than any number of single exposures. The depth obtained in them will often show an infected superimposed posterior ethmoid cell in what appeared on the flat roentgenogram as an infected sphenoid sinus.

In one of my slides a definite outline of one frontal sinus was seen. Its fellow was apparently absent. The roentgenologist's report read: "A failure of development or absence of the left frontal sinus." A second set of stereoroentgenograms demonstrated a left frontal sinus of equal size and shape as the right, which observation was proved to be correct at operation.

Experience has taught me that in cases in which roentgenograms show a single frontal sinus confined exclusively to one side of the forehead and ending abruptly against what should be the intrasinus septum, the other frontal sinus is present but has failed to register, owing to the inability of the rays to penetrate the thickened anterior wall.

In another slide the anterior wall was so thickened that the sinus was obliterated except at its greatest depth. The diffuseness of the proliferative osteitis was confined to the one side. This form of osteitis is due to chronic irritation of the bone. Starting at the point of injury, it gradually fans outward in the anterior wall. By the time that it reaches the periphery of the sinus the anterior wall has

become so thickened (by ivory-like bone) that the roentgenogram appears opaque, like the marginal bone of the sinus cavity.

In a case that two roentgenologists and rhinologists diagnosed as one of absence of a frontal sinus, after several attempts I succeeded in sounding this sinus. Two slides showed the sound in place, proving to the patient not only the presence of a chronically infected sinus but the necessity of operation.

Dr. F. M. Law, New York: The roentgenologist arrives at the point where he is able to make a diagnosis and feels perfectly satisfied. Then some one presents a condition which places an uncertainty in his mind. This means a closer cooperation between the rhinologist and the roentgenologist. It would have been impossible for any roentgenologist to make a diagnosis on the basis of the roentgenograms that Dr. Skillern presented without his assistance in the interpretation. This also illustrates the point that it is necessary for the roentgenologist to have some clinical evidence, because there may be an opacity due to postoperative repair on a roentgenogram, a picture which would resemble a diseased sinus.

Dr. Skillern spoke about sending his patients for roentgen examination before anything has been done. This is wise. An allergic condition may change the appearance of the roentgenograms. This was illustrated forcibly in the case of a patient who was sensitive to watermelon. The patient was in the rhinologist's office with perfectly normal-appearing sinuses and was sent for a roentgen examination. Lunch time arrived, so the patient concluded that he would go to lunch before the examination. During lunch he ate a piece of watermelon. When I received the roentgenogram the antrum showed severe involvement causing complete occlusion (4+). It could not have been more than an hour from the time that the surgeon saw the patient to that of the roentgen examination. I happened to know the patient and found that watermelon had been eaten. There was a possibility of allergy.

TREATMENT OF PHARYNGEAL CANCER

FRACTIONAL DOSE METHODS OF EXTERNAL IRRADIATION

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BUFFALO

The optimistic reports following the application of the more recent radiologic methods for the treatment of pharyngeal cancer by external irradiation with daily fractional doses not only have furnished a new stimulus to therapeutic endeavor but also have served to usher in a new radiologic era which augurs a better understanding of the basic principles involved and a more hopeful outlook for future progress in the conquest of the more radioresistant lesions. To the French school under Regaud and Coutard belongs the credit of popularizing and stressing the value of such protracted treatment with fractional doses in therapy both with the gamma and with the roentgen rays. The most important principles involved may be stated as (1) the optimal daily fractioning of the total dose, (2) the total duration or chronology of treatment in days or weeks and (3) the production of a more intense reaction of the skin and mucous membrane, variously known under the captions epidermolysis, epidermitis, epithelitis and mucositis. With these facts in mind, a brief review of the evolution of such technics as practiced by my associates and me at the State Institute for the Study of Malignant Diseases for the past three or four years may be of sufficient general interest to justify a detailed account of the methods and some of the results commonly obtained.

In this presentation an attempt is made not to advance these more recent methods as a panacea but rather to call attention to the frequent and often complete regression which is commonly observed even in advanced cases. Although complete arrest is possible in a limited number of cases with external irradiation as the sole agent, as illustrated in some of the cases to be reported, in many the use of supplemental irradiation is advisable, generally in the form of radon seeds or radium tubes, whichever can be more conveniently employed, as an additional safeguard against local recurrence. The cases reported are therefore presented not to point out exceptions but to give the impression of what may be frequently achieved by intensive therapy in cases previously regarded as unfavorable material as well as to suggest some of the failures and opportunities for improvement in the present technic.

From the State Institute for the Study of Malignant Diseases, Burton T. Simpson, M.D., Director.

FRACTIONAL DOSE METHODS

The treatment of pharyngeal cancer by fractional dose methods of external irradiation as carried out at the Institute may therefore be classified into that administered by radium pack and that administered by roentgen radiation. The pack methods, from the inherent daily repetition of dosage and the long duration necessary for the administration of the daily increments, are virtually similar to the method of protracted fractional roentgen irradiation as outlined by Coutard. Both, therefore, with modifications of the latter, will be included under this heading of fractional dose methods.

I shall speak of methods of application of radium to the surface and of the methods employing roentgen rays, which, for purposes of description, may be further subdivided.

1. By one method the dose is given at 0.11 angstroms effective wavelength at 200 kilovolts with a Thoreau filter of 0.5 mm. of tin, 0.25 mm. of copper and 1 mm. of aluminum placed in the path of the rays in the order mentioned and giving the approximate equivalent filtration of 3 mm. of copper. Such treatment is practically similar to that of Coutard except for a higher roentgen (r) dose per minute rate. In fact, it is a modification of the Coutard method developed by the institute.

2. By another method the dose is given at 0.16 angstroms effective wavelength at 200 kilovolts with a 0.5 mm. copper filter. (*a*) Fractional doses are given daily on a single field for seven or eight treatments, making a total of 2,000 r of primary radiation, or on opposite fields on alternate days, thus giving a daily treatment for from twenty to twenty-five days of a total of from 3,000 to 3,500 r of primary radiation per field. The latter technic is a modification of the foregoing method using lighter filtration. (*b*) A treatment is given on a single field or by cross-fire every two or three days for from three to six treatments and may be continued for from three to five weeks by the saturation method. This is the older technic of divided doses previously described. (*c*) According to the massive dose method, the total exposure is given at one sitting. This method at present is reserved chiefly for experimental comparison.

The pack method of treatment with radium is generally carried out with one or two packs. The larger pack contains 4 Gm. of radium element and has a filter consisting of 1 mm. of platinum, 1.5 mm. of steel, 0.5 mm. of copper and 1 mm. of aluminum. The portal generally used for pharyngeal tumors is 10 by 10 cm., while the distance from the skin is generally 10 cm. The pack delivers approximately 6 r per minute for the 6 cm. distance and 4 r per minute for the 10 cm. distance, as measured by the Victoreen dosimeter. With the second pack, which is a combination of element and radon, the filter is 1 mm. of platinum,

1 mm. of bakolite, 1 mm. of copper and 1 mm. of aluminum. With this pack a smaller portal can be used, generally 5 by 5 cm. at a distance of 6 cm. With these two packs it is customary to use a single field over the side of the lesion, to attack the tumor by cross-fire by two opposite fields or by the addition of a posterior field at a distance of 10 cm., to supplement the two lateral fields, generally given at a 6 cm. distance with a 5 by 5 cm. portal.

With the large pack at a distance of 10 cm., my colleagues and I customarily give 10,000 milligram hours daily for from eight to ten days, and with the smaller, combination pack at a distance of 6 cm., 3,000 milligram hours daily for twelve days. Such a dose generally calls forth a moderate mucosal and cutaneous reaction and often much shrinkage in the size of the tumor. In almost all but the comparatively radiosensitive growths such treatment must be supplemented by radium placed interstitially, either preceding or following the pack treatment.

The following three cases are reported to illustrate the pack technic.

REPORT OF CASES

CASE 1.—H. W. L., a man aged 59, was admitted to the hospital on Dec. 22, 1933, with an epithelioma (pearl cell type) of the left tonsil of three months' duration, with ulceration through the adjoining region of the soft palate.

A 4 Gm. pack was given first on December 24 and was continued daily until Jan. 4, 1934, making ten treatments of 10,000 milligram hours daily for a total of 100,000 milligram hours over the left peritonsillar region at a distance of 10 cm. On February 14 four gold radon seeds of 1.8 millicuries each were implanted in the left supratonsillar residual for a total of 957.6 millicurie hours. Complete clinical healing resulted. Some months later slight recurrence was noted, which necessitated the use of a surface mold against the tonsil, with resulting healing.

CASE 2.—G. M., a woman aged 44, was admitted to the hospital on Jan. 10, 1934, with an epithelioma (pearl cell type) measuring approximately 1 by 2 cm. and involving the left ventricular band and contiguous aryepiglottic fold. The cords were not involved. No nodes were palpable in the neck.

A combination pack was administered on January 13, and the treatment was continued daily until February 8 at a skin distance of 6 cm., giving approximately 3,000 milligram hours daily for twelve days on the right side of the neck and in the region of the larynx and the same amount on the left side through a 5 by 5 cm. portal. On February 9 a posterior portal was selected, through which, with the 4 Gm. pack, 8,000 milligram hours daily was given for six treatments at a distance of 10 cm., making a total of 120,000 milligram hours to all three fields. On March 26 there was complete clinical healing except for some slight immobility of the left cord. Examination four months later revealed recidivation, and since then the patient has had steady progression of the growth with metastasis.

CASE 3.—R. T., a woman aged 70, was admitted to the hospital on Dec. 7, 1932, with a complaint of a sensation of fulness in the throat for the past year. For the past month this had become worse and was accompanied by soreness. A hard infiltrating mass approximately 2 cm. in diameter with an ulcerating surface was noted on the posterior wall of the oropharynx, which on section proved to be

a pearl cell epithelioma growing in the lymphoid tissue. No palpable nodes were noted in the neck.

A combination radium pack was administered over the right and the left side of the neck for 5,000 milligram hours daily on alternating sides for eight days at a distance of 6 cm., thus giving a total of 20,000 milligram hours to each field. The treatments were finished on December 15. On subsequent examination on Jan. 9, 1933, the lesion had completely disappeared, and scaly desquamating erythema was noted on both sides of the neck. Over two years later there had been no recurrence nor had additional treatment been given.

The modified Coutard technic, as we carry it out, consists in its typical form of approximately ten or eleven daily treatments to a 10 by 15 cm. field over the side of the lesion, with three or four supplemental treatments on the opposite side of the neck, continued until epithelitis is produced. Such treatments are given at a target distance of 50 cm. at 200 kilovolts and a rate of 23 r per minute through a Thoreau filter equivalent to approximately 3 mm. of copper. The daily increments are generally 340 r, tissue-measured for better comparison with factors as noted by Coutard, carried to a total amount of radiation of 5,000 or 5,500 r. I find that a dose of approximately 4,500 or 5,000 r is necessary to produce epidermitis. In primary radiation this would amount to approximately 3,000 r.

The following cases are reported in illustration of this method.

CASE 4.—J. W., a man aged 58, was admitted to the hospital on Jan. 20, 1933, with an ulcerating lesion of nine months' duration involving the right side of the larynx and epiglottis. There was a large mass of palpable nodes in the right side of the neck. The lesion was clinically malignant, probably an epithelioma.

Treatment according to a modification of the Coutard method was started on January 25, with a 3 mm. copper filter. Eight treatments were given through a 10 by 15 cm. portal at a target distance of 50 cm., at a rate of 18 r per minute, 360 r of primary radiation being given daily eight times over the region of the right side of the neck and larynx. Five supplemental treatments of the same nature were given over the left side of the neck.

On May 9 some residual ulceration on the right edge of the epiglottis was coagulated. The metastatic mass in the right side of the neck had disappeared.

On October 4 complete clinical healing had resulted. The superior portion of the epiglottis had sloughed away, leaving a healed and healthy looking base. The patient died over a year later of an intercurrent illness but showed no signs of recurrence.

CASE 5.—A. R., a man aged 59, was admitted to the hospital on May 8, 1933, on account of epithelioma (pearl cell type) of the epiglottis with definite nodes in the region of the right sternocleidomastoid muscle.

Treatment according to the modified Coutard technic with a Thoreau filter was started on May 8, with nine daily treatments of 230 r (primary) at the rate of 23 r per minute, followed by five daily treatments to the opposite side of the neck and region of the larynx with the same 10 by 15 cm. portal and at a target distance of 50 cm.

On August 9 a small residual lesion was noted on the right edge of the epiglottis. The enlarged nodes in the tongue had disappeared. On August 22

four gold radon seeds of 2.2 millicuries, or 1,170.4 millcurie hours, were implanted between the base of the tongue and the epiglottis.

There was complete clinical healing for over a year, with no signs of recurrence in the nodes. The patient died later of other causes.

CASE 6.—E. S., a woman aged 52, was admitted to the hospital on Sept. 27, 1932, with epithelioma of the left tonsil measuring 3 by 5 cm. and involving the anterior pillar. There was a hard node at the angle of the left jaw the size of an almond.

Sixteen gold radon seeds were implanted in the tonsillar lesion, a total of 29.1 millicuries or 3,870.3 millicurie hours being administered. This was followed by disappearance of the tonsillar lesion and a radium slough behind the posterior pillar. On May 29, 1933, the modified Coutard treatment was applied to the left side of the neck and tonsillar region in an attempt to cause regression of the nodes. Nine treatments through a 10 by 15 cm. portal at a target distance of 50 cm., with a Thoreau filter, were given at a rate of 23 r per minute for 230 r of primary radiation daily. This was followed by three similar treatments over the opposite side of the neck and tonsillar region.

Since September 30 there have been no signs of recurrence. The node at the angle of the right jaw disappeared. Complete clinical healing has lasted two years and six months.

CASE 7.—T. B., a man aged 65, was admitted to the hospital on Nov. 22, 1933, with a complaint of irritation of the pharynx with spitting of blood for the past six or seven months. He had lost 25 pounds (11.3 Kg.). On examination a fissured mass was observed on the posterior pharyngeal wall, which almost occluded a view of the larynx. A section from this mass showed it to be a carcinoma, which lay deeply under the mucosa and presented some inflammatory reaction. There were no nodes in the neck.

Treatment according to the modified Coutard method was started on November 25, with a Thoreau filter and a daily dose of 184 r over alternating fields of 10 by 15 cm. to the right and the left sides of the neck at a target distance of 50 cm. for a total of twenty treatments, ten being given to each field in twenty-six days. There was only a slight regression of the mass. On Jan. 4, 1934, gold radon seeds were implanted in the lesion for a total of 3,351.6 millicurie hours. On January 21 considerable edema was noted, but the tumor could not be observed. The patient felt better and swallowed better. On June 20 there were no visible signs of the growth, and on Jan. 30, 1935, there were no signs of recurrence, and no nodes were palpable in the neck. The patient is well at the time of writing.

A more recent modification which we have developed consists in irradiation at an effective wavelength of 0.16 angstroms daily over a single field at a rate of 65 r per minute, giving up to 280 r of primary radiation for each of seven treatments when treatment is omitted on Sunday or, as is done at the Memorial Hospital, 300 r daily to alternate sides of the neck administered for approximately twenty-five days, giving approximately ten treatments every other day through each of these portals. Such treatment generally evokes epithelitis about the end of the second week and epidermitis at the end of the fourth or fifth week. It is similar to the modified Coutard technic and more recently has replaced it on account of speed and simplicity of application.

CASE 8.—E. T. P., a man aged 65, was admitted to the hospital on Feb. 5, 1934, with a 1 mm. epithelioma of the pharyngeal wall, the left vallecula and the left arytenoid region of six months' duration. Multiple palpable nodes were present in both sides of the neck.

Roentgen treatment with a 0.16 angstrom effective wavelength was started on February 7. A dose of 240 r was given daily for eight treatments, or 1,920 r in nine days, over the left side of the neck and the laryngeal region, with a 10 by 15 cm. portal at a target distance of 50 cm. and at a rate of 65 r per minute. By April 25 the hoarseness had almost disappeared; the structures of the left side of the larynx were still somewhat fixed and swollen, and the left cord was slightly injected, but no definite tumor tissue could be identified. The palpable nodes had disappeared from the left side of the neck. A few small ones remained under the right sternocleidomastoid muscle. The patient felt much better and grateful for the marked palliation. He died eight months after the first admission to the hospital of recurrence and metastasis.

CASE 9.—O. F. D., a man aged 65, was admitted to the hospital on Oct. 27, 1933, with epithelioma of the laryngopharynx and epiglottis of one year's duration. He could swallow only fluids and had lost 60 pounds (27.2 Kg.). The tumor of the epiglottis was so large as to occlude the view of the larynx. No nodes were palpable in the neck, but the condition seemed hopeless.

The patient was lost trace of and did not return until Feb. 13, 1934, when treatment was started with 0.16 angstroms effective wavelength over two opposite fields of the neck of 10 by 15 cm., covering the region of the larynx, at a target distance of 50 cm. and a rate of 65 r per minute, alternating the right and left fields for twenty treatments, thus giving a total of 3,500 r of primary radiation on each side of the neck or 4,944 r tissue-measured, with 4,416 r in the tumor. This was followed by marked reduction in the size of the tumor. The right arytenoid region was swollen and edematous, but the patient felt well, ate well and regained his lost weight. After he was clinically well for one year, metastasis in the lungs was noticed. At autopsy no local recurrence could be demonstrated in the laryngopharynx or local nodes.

CASE 10.—W. H. T., a man aged 80, was admitted to the hospital on March 26, 1934, with a pearl cell epithelioma in the right tonsillar region which had involved the pillars and the base of the tongue. There was also a metastatic mass of glands at the angle of the right side of the jaw which, while movable, was the size of a pigeon's egg. The condition looked hopeless.

Treatment with a 0.16 angstrom effective wavelength was started immediately. Two hundred and eighty r was given daily, one day to the right side of the neck and tonsillar region and the next day to the left side of the neck and tonsillar region for a total of sixteen treatments with a 10 by 15 cm. portal at a target distance of 50 cm. and a rate of 65 r per minute. By April 15 the right tonsil was much reduced in size, the superficial ulceration had healed and the nodes in the right side of the neck had been reduced to approximately half their original size. On May 22 there were no signs of a lesion in the right tonsil, and the nodes had been reduced to small fibrous nodules. When the patient was last seen, on March 6, 1935, there was no sign of recurrence either locally or in the glands. The pharynx and larynx were normal, and the patient was feeling as well as ever.

CASE 11.—E. A. R., a man aged 72, was admitted to the hospital on Sept. 5, 1934, with a complaint of soreness of the left side of the throat of one month's duration, accompanied by a movable node in the left cervical region. Examina-

tion revealed an ulcerating lesion involving the left ventricular band and aryepiglottic fold, which on section proved to be a pearl cell epithelioma.

Treatment with a 0.16 angstrom effective wavelength was started on the same day, 280 r being given daily, with some interruptions, to alternate fields on the right and left sides of the neck at a target distance of 50 cm.; eighteen treatments were given in twenty-eight days. The patient returned on December 14, when the lesion had apparently healed and the movable node in the neck had disappeared. When last seen there was no sign of recurrence in the hypopharyngeal and laryngeal region. The patient had given up his previous hopeless outlook and was feeling well.

COMMENT

External irradiation such as that described should seldom be repeated and only after a prolonged interval during which the hair has regrown on the part.

Estimated Amounts of Primary Roentgen Radiation Required for Various Cutaneous Reactions and Their Ratios Compared with the Threshold Erythema Dose

	Roentgen Rays				Radium	
Reactions	Effective Wavelength, 0.16 A; T. R. Coeff.,* 0.08	Ratio	Effective Wavelength, 0.11 A; T. R. Coeff., 0.06†	Ratio	Effective Wavelength, 0.017 A; T. R. Coeff., 0.04	Ratio
Threshold erythema dose...	525 r 65.6%	1.0	755 r 65.6%	1.0	1,600 r 65.6%	1.0
Therapeutic erythema dose	800 r 100%	1.5	1,200 r 100%	1.5	2,400 r 100%	1.5
Epidermolytic reaction.....	1,300 r 165%	2.5	2,000 r 165%	2.5	4,000 r	2.5
Necrotizing reaction.....	1,500 r 178%	2.9	.....	...	.....	...

* T. R. Coeff. indicates tissue recovery coefficient.

† The values are recorded in roentgens of primary radiation to avoid the controversy which has arisen as the result of the need of a universally accepted and perfected small ionization chamber. To translate the values for roentgen irradiation with a 10 by 15 cm. portal into values for secondary or scattered roentgen irradiation, the figures given should be increased approximately 50 per cent.

The older method of divided doses may still be used for those patients who will not submit to the newer technic or when the lesion is supposedly radiosensitive. Massive doses apparently have no place in present-day therapy of these tumors. In a few experimental cases we have, however, produced typical epidermolysis by a massive dose of 2,170 r of primary radiation at 0.11 angstrom effective wavelength and a lesser reaction more similar to the usual former therapeutic erythema by a single dose of 1,380 r. With the 0.16 angstrom effective wavelength we have similarly produced marked epithelitis and epidermitis by a massive dose of 1,280 r of primary radiation in one case and only intense pigmentation and mild redness in two others with 1,200 r similarly administered. These experimental data compare very well with the cumulative effective roentgen values computed by the daily mean tissue recovery coefficient. The rela-

tion of the epidermolytic, therapeutic and biologic doses of primary roentgen irradiation and the mean daily tissue recovery coefficients are shown in the table.

Our experience in the treatment of approximately five hundred patients by the methods described has suggested the following hypothetic conclusions:

1. The epidermolytic dose is approximately 65 per cent higher than the former therapeutic dose.

2. The cumulative effective dose of primary roentgen radiation necessary for the production of epidermolysis computed by means of the

The epidermolytic reaction following a massive dose of primary radiation of 1,234 r at a 0.16 angstrom effective wavelength.

appropriate tissue recovery coefficients is approximately 1,300 r for the 0.16 angstrom effective wavelength and 2,000 r for the 0.11 angstrom effective wavelength. These figures agree well with the values ascertained by experimental massive single doses as mentioned previously.

3. Whereas a high total dose of roentgen radiation is often reported as used in daily fractional protracted technics, such high values are misleading and devoid of significance unless the total time over which the treatments are given and the daily increment in roentgens are also specified. The important consideration, therefore, is not the highest total dosage in roentgens which can be reported but rather a high

enough cumulative effective dose to the skin or tissues to cause regression of the lesion without permanent damage to the tissue bed. Such a desired cumulative effective dose can be attained only by a properly selected daily increment of roentgens in accordance with the effective wavelength employed.

4. Whereas heavier filtration and a low roentgen dosage per minute rate were formerly considered essential, we believe that equally good results may be achieved with roentgen rays of the customary 0.16 angstrom effective wavelength and with the usually more rapid rate per minute.

5. By adopting these higher epidermolytic doses as routine whenever feasible, we have been more able to combat successfully these previously resistant tumors of the pharynx and to effect primary healing in a much larger group than was formerly possible with the older method. It is, however, too early to make any definite pronouncement of arrests over a period of five years that will be obtained.

6. While we concede that the restatement of the principle of daily fractioning of the dose, the Parisian idea of increasing the total duration of treatment with the ultimate production of epidermolysis and the newer concept of radiosensitivity have added greatly to the possibilities of combating these lesions, there still remain other factors, such as the reaction of the tissue bed and the general bodily responses of the host, which may ultimately explain why it is impossible to predict or duplicate results in otherwise similar lesions under similar irradiation therapy.

These methods are not suggested as final but are merely reported in illustration of the present evolutionary trends by which we may ultimately hope to make further conquest of this realm of pharyngeal malignant processes generally considered refractory to other therapy.

XANTHOMA OF THE PHARYNX AND LARYNX

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ROCHESTER, MINN.

Xanthomas of the pharynx and larynx are of interest from a diagnostic standpoint on account of their rarity. At the Mayo Clinic during the last four years we have examined four patients with this condition. Two of the cases were reported by Finney, Montgomery and New in 1932, and since that time I have seen two additional cases. Previous to 1930 this condition in the upper respiratory tract had not been recognized in the cases which were seen at the clinic. At the time of the previous report twenty-six cases of xanthoma multiplex had been seen at the clinic, and in the literature I was able to find only sixteen cases in which the mouth and pharynx were affected and only three cases in which the larynx and trachea were involved.

REPORT OF CASES

CASE 1.—A married woman, aged 48 years, came to the clinic on May 25, 1933 because of difficulty in swallowing which had been present for the past three months. A year ago, palpitation of the heart had developed after an attack of influenza. A physician who examined her at that time had found that the value for the hemoglobin was low, and he had made a diagnosis of pernicious anemia. She had responded well to liver therapy and, except for the low value for the hemoglobin, she had been getting along very well. There had not been numbness, tingling or difficulty in the use of extremities. In the last three months she had had attacks of vomiting once or twice a week. She had attributed these attacks to the use of certain kinds of food, especially fats. She never had been jaundiced. For the last three months she had complained of difficulty in swallowing and had found that it had been necessary to eat bland foods and to chew them very well in order to get them down. During the last month the condition had become much worse. She recently had noticed some hoarseness.

Examination of the pharynx revealed extensive yellowish deposits (fig. 1) on the anterior pillars of the tonsils, on each side of the palate, in the hypopharynx, on the epiglottis and on the vallecula. There was one small nodule in the subglottic region, below the anterior commissure. There were multiple small nodules in the posterior wall of the hypopharynx. Both of the arytenoid cartilages appeared to be scarred and to be pulled forward. General examination revealed a very small nodule in the left midcervical region and another small nodule on the back of the right shoulder; otherwise there was not any involvement of the skin. There were 3,600,000 erythrocytes and 4,400 leukocytes per cubic millimeter of blood. The value for the hemoglobin was 12.4 Gm. per hundred cubic millimeters of blood. The differential blood count revealed the following percentages: lympho-

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From the Section on Laryngology, Oral and Plastic Surgery, the Mayo Clinic.
Read at the meeting of the American Laryngological Association in Toronto, Ontario, on May 29, 1935.

cytes, 59; monocytes, 2; neutrophils, 37; eosinophils, 1; basophils, 0.5, and myelocytes, 0.5. There were slight poikilocytosis, marked anisocytosis and slight polychromatophilia. The percentage of reticulated erythrocytes was 1.3. The specific gravity of the urine was 1.016, the reaction was acid, and there was no albumin or sugar. Roentgenologic examination of the stomach and duodenum did not reveal anything abnormal. The flocculation test was negative. The bromsulphalein test of hepatic function did not reveal retention of the dye. Chemical analysis of the blood disclosed the following values: for cholesterol, 84 mg. per hundred cubic centimeters of plasma; for fatty acids, 237 mg., and for the total lipoids, 321 mg. A specimen of the deposit which was situated in the pharynx was obtained for biopsy, which showed that the condition was xanthoma (fig. 2).

The pernicious anemia was treated, and the patient was sent home to continue this treatment, which was considered more important than treatment of the xanthoma. She was advised to undergo a course of roentgenotherapy if the xanthoma progressed.

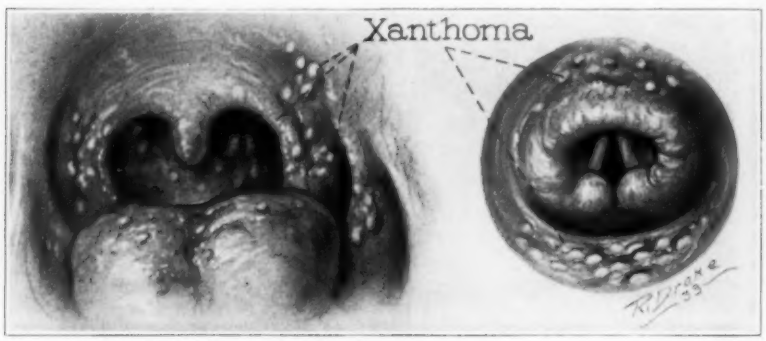

Fig. 1.—Extensive deposits of xanthoma on the pharynx and hypopharynx. There are some thickening and scarring of the arytenoid cartilages which pull them forward.

Case 2.—A married woman, aged 46 years, came to the clinic on Aug. 13, 1934 because of hoarseness which had been present for eight months. The hoarseness had gradually increased in severity. The patient had not had any pain, cough, bleeding or increased amount of mucus. She said that her throat felt tired after much talking. Her general health had been good, and she had not lost weight.

Examination revealed a tumor that involved the posterior three quarters of the true and false vocal cords on the left side (fig. 3). The tumor had produced slight limitation of movement of the vocal cord. The surface of the tumor was not ulcerated but was yellowish and slightly nodular in appearance, as in the other cases of xanthoma that I have seen. General examination revealed nothing of note. The specific gravity of the urine was 1.014, and the reaction was acid. There was no albumin or sugar in the urine. There were 4,550,000 erythrocytes and 7,500 leukocytes per cubic millimeter of blood. The value for the hemoglobin was 12.5 Gm. per hundred cubic centimeters of blood, and the flocculation test was negative. Roentgenologic examination of the chest did not reveal anything abnormal. Roentgenologic examination of the larynx did not reveal any involvement of the cartilage. A thyrotomy was advised for the laryngeal tumor, which was thought to be a xanthoma or possibly a carcinoma of the mixed tumor type. A

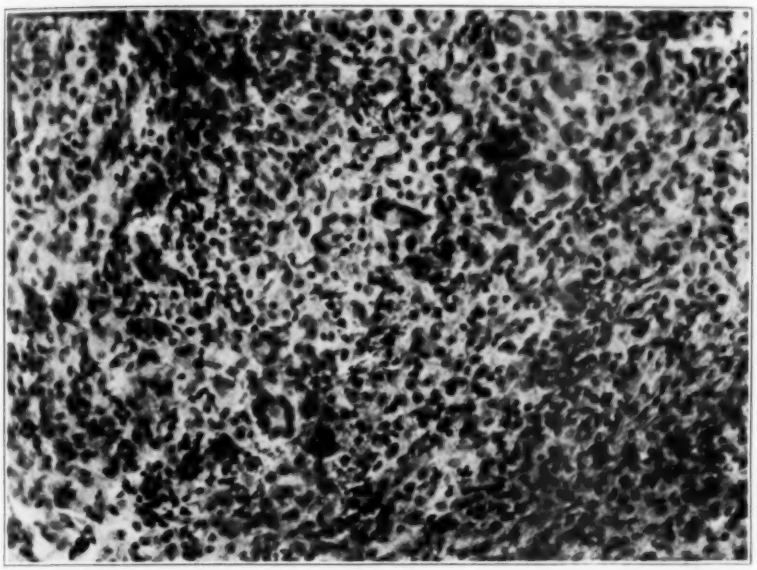

Fig. 2.—Xanthoma of the pharynx; × 205. Note the pale-staining vacuolated xanthoma cells and "Touton" giant cells.

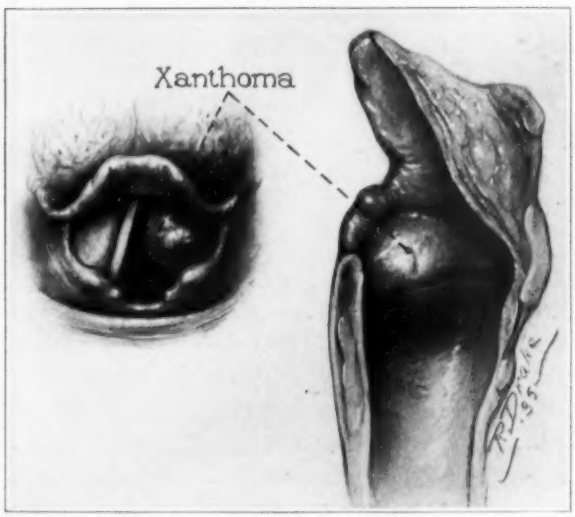

Fig. 3.—Xanthoma of the left side of the larynx.

preliminary tracheotomy was done, and following this the larynx was explored by means of a thyrotomy. The tumor bulged the true and false cords in their posterior three quarters over an area about 2.5 cm. in diameter. The mucous membrane was not ulcerated but was yellowish and nodular. By means of a longitudinal incision just below the vocal cord the tumor was removed, and the base was destroyed with surgical diathermy. The tumor was not completely encapsulated but had infiltrated into the muscle. Microscopic examination revealed that it was a xanthoma (fig. 4). The patient made an uneventful recovery and was examined again on Feb. 19, 1935. At this time there was no evidence of return of the growth and the patient had a good speaking voice.

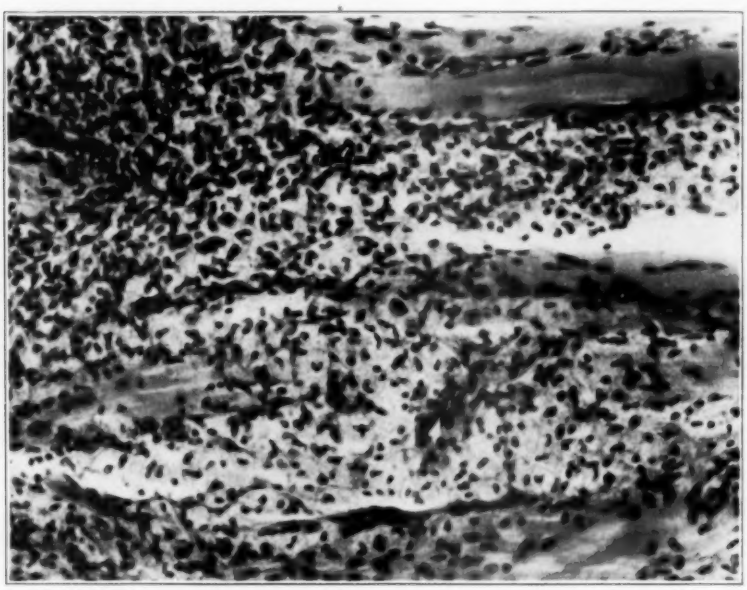

Fig. 4.—Photomicrograph of a section of the laryngeal tumor; × 205. Note the pale staining vacuolated xanthoma cells. The lesion infiltrates into the muscle.

COMMENT

The etiology of xanthoma is not known, but it is thought that an abnormality of lipid metabolism associated with some local condition is responsible for the deposits of fat. In many cases, however, there is not any demonstrable metabolic disturbance. In some cases the condition is associated with diabetes mellitus, and hypercholesteremia has been thought to be an essential antecedent of xanthoma. In case 1 the condition was associated with pernicious anemia, and in case 2 the general examination did not disclose any etiologic factor. Case 1 seems to be of the type in which the condition is associated with a general metabolic condition. In nine of sixteen cases of xanthoma in which the values for cholesterol and fat in the blood were determined at the

clinic the values were found to be higher than normal. In case 2, however, the localized laryngeal tumor may be similar to the fatty degeneration that is present in fibromas, although microscopically the picture is the same as that found in those tumors which are associated with general metabolic disturbances. Multiple nodules or plaques may be present in the mouth, pharynx, larynx and trachea. These present a smooth surface, which sometimes is nodular and has a yellow color. Finney, Montgomery and New have reported that although the lesions may vary in number, size and distribution the histopathologic picture is similar for all types of xanthoma. The pathologic process may be divided rather arbitrarily into an early or inflammatory stage, a tumor stage and a stage of regression or fibrosis. The most prominent feature is the presence of the xanthoma or foam cells which, when stained for fats, are seen to be laden with various lipids, and are apparently derived from the reticulo-endothelial system. Frequently, especially in the tumor stage, numbers of "Touton" giant cells are seen; these are characterized by a central circular arrangement of their nuclei with a peripheral zone of lipid-containing cytoplasm.

The scarring which was present in case 1 of the first report and in case 1 of this paper is worthy of note. In case 1 of the first report tracheotomy was necessary on account of the scarring of the supraglottic region, and the mucous membrane on the disk of cartilage which was removed at the time of the tracheotomy showed the same microscopic picture as did xanthomatous nodules which were situated elsewhere in the pharynx.

Many types of treatment have been advocated for this condition. The nodules or plaques may be excised or removed with the cautery or with diathermy. Various general measures have been advocated, but the results have been indifferent. In some of the cases in which the lesion is associated with diabetes mellitus a regimen with or without the administration of insulin has produced little improvement and the results have not been uniform. Spontaneous disappearance may occur. In the first two cases that were seen at the clinic, in which medical treatment was used, no material change was produced by any form of treatment. Roentgenotherapy and a diet that was low in calories and fat were employed. In case 1 no treatment for the xanthoma was given on account of the fact that the patient had pernicious anemia and treatment for this was considered to be more important than treatment of the xanthoma. In case 2 the tumor was removed by means of a thyrotomy. There was no recurrence of the tumor, and the functional result was good.

LATE CHANGES IN THE MUCOSA OF THE FRONTAL SINUSES AND NOSE OF DOGS FOLLOWING IONIZATION

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The value of ionization as a sound method of treatment of allergic conditions of the nose should be judged not only by the amount of relief from local symptoms which follows but by the derogatory effects which it may bring about in the tissues. Too often an unsound empirical method has been adopted solely because of enthusiasm for something new or sensational, and one has eagerly rushed to apply the method of cure while it was still in vogue.

There are certain fundamental laws governing tissue reactions which may not be ignored, and those concerned with the reaction of repair in connective tissue are the most inflexible. The ever-present anxiety to prevent the formation of adhesions and synechiae following an operative procedure is evidence of a tacit respect for these laws. While it is readily acknowledged that interference with function is caused by fibrosis within the parenchymatous visceral organs, the fact is not widely appreciated that adhesions (fibrosis) may be activated within the tissues of the nose as well as between the gross structures by undue irritation and thus cause serious interference with the proper functioning of these tissues.

From experiments made last year I [1] concluded that definite destructive changes were brought about in the mucosa of the frontal sinuses of dogs by the ionization of a solution of zinc sulphate in the sinuses. These changes consisted of ballooning, fragmentation and complete destruction of the surface epithelium in most places, marked edema and partial disintegration of the subepithelial tissues and extravasation of free red blood cells into these tissues from greatly dilated and ruptured capillaries.

As a result of these immediate extensive changes it was felt that in the process of regeneration of the mucosa more extensive permanent changes might be brought about, and it was with the idea in mind of studying the possible progressive changes that the following experiments were conducted.

From the Department of Otolaryngology, Oscar Johnson Institute, Washington University School of Medicine.

1. McMahon, B. J.: Effects of Ionization on the Mucosa of Frontal Sinuses of Dogs, Ann. Otol., Rhin. & Laryng. **43**:643 (Sept.) 1934.

PROCEDURE

Healthy dogs, free from nasal infection, were selected and prepared by the intraperitoneal injection of from 6 to 10 cc. of a solution of amytal, according to the size of the animal. The electrode used was composed of zinc, 85 per cent; tin, 10 per cent, and cadmium, 5 per cent. The solution ionized contained 8.92 grains (0.57 Gm.) of zinc sulphate, 1.42 grains (0.09 Gm.) of stannic chloride and 0.45 grains (0.03 Gm.) of cadmium chloride per ounce (28.4 Gm.). (These are the manufacturer's figures.)

The choanae were blocked with a postnasal plug composed of a rubber finger cot filled with cotton and held in place by an attached string passed through the nonionized side of the nose. The electrode, thinned to prevent trauma and wrapped with long fiber cotton, was carefully introduced into one side of the nose. That side was then filled with the solution so that every portion of the mucosa would be affected, as it is impossible to pack the nose completely with cotton without causing considerable trauma. The galvanic current, 2.5 milliamperes, was per-

Microscopic Observations After Ionization

	Dog	1	2	3	4	5 (Sinus)	6 (Sinus)
	Length of interval	18 Hrs.	2 Wks.	4 Wks.	7 Wks.	7 Wks.	12 Wks.
Epithelium	Fragmentation	++					
	Thickening	+++	+	+	+	+	+
	Metaplasia					P	P
	Cilia		P	P	P	P	P
Tunica Propria	Edema	+++					++
	Fragmentation	++					
	Thickening	+++	+	+	++	++	+++
	Young connective tissue cells	+	+++	++	+++	++	++
	Fibrosis		+	++	+++	++	+++
	Capillaries	D, R	D	N	D	N	D, I
	Glands	D	D	C	C, D		
	Periosteal thickening			+	++	++	+++
	Hyperostosis						+++

+ indicates mild; ++, moderate; +++, extreme; C, compressed; D, dilated; I, increased; N, normal; P, present, and R, ruptured.

mitted to flow for twenty minutes, with the positive electrode in the nose and the negative electrode completing the circuit at a shaved area on the back of the neck. This routine was followed in dogs 1, 3 and 4, while in dog 2 the wrapped electrode, kept saturated with the solution during the time of the ionization, was used without a postnasal plug. In dogs 5 and 6 both frontal sinuses were filled with the solution and ionized at 2.5 milliamperes for twenty minutes.

The dogs were killed after different intervals (table), and the heads were placed in a solution of formaldehyde, U. S. P. The nasal or sinus blocks were cut after twenty-four hours, decalcified, stained with hematoxylin and eosin and sectioned serially.

MICROSCOPIC OBSERVATIONS

Dog 1.—The right side of the nose was ionized and the dog was killed in eighteen hours. The epithelium on the right side contained cells higher than those observed on the unionized side, elongated on account of granular fluid in the protoplasm and vacuolation. There was fragmentation of individual and large blocks of cells with round cells in large numbers infiltrating through to the surface from the subepithelial tissue. Cilia were generally unrecognizable. In the subepithelial tissue edema varied from moderate to extreme. Round cell infiltration varied from

mild to marked. The entire tissue was fragmented and separated from the periosteum in various places. The glands were either swollen or fragmented. The blood capillaries were engorged generally, some being ruptured. Large numbers of free red blood cells were present in many places.

Dog 2.—The right side of the nose was ionized, only a wrapped electrode being used. The mucosa became grayish pink along the track of the electrode. The animal was killed in two weeks. The epithelium on the right side was definitely thickened and more concentrated and higher than that on the unionized side. In some areas more goblet cells were seen and cilia were present. Examination of the

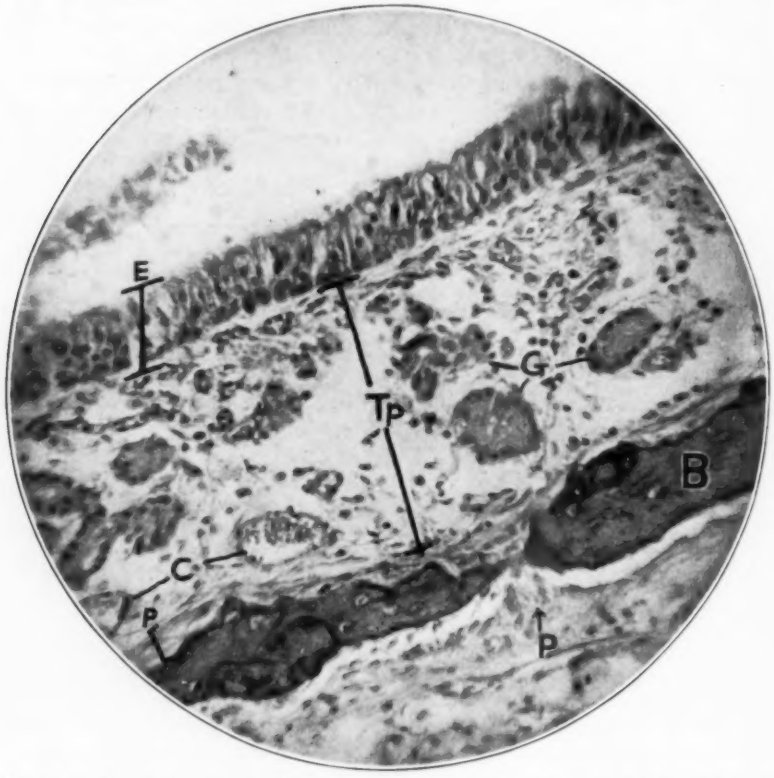

Fig. 1.—Normal mucosa of the turbinate. The tunica propria has the usual number of connective tissue cells in the stroma. In figures 1 to 9 *B* indicates bone; *C*, capillary; *E*, epithelium; *F*, fibrosis; *G*, gland; *I*, ionized side; *L*, left; *N*, nerve; *P*, periosteum; *R*, right; *S*, septum; *Sp*, space; *T*, turbinate; *Tp*, tunica propria; *U*, unionized side, and *X*, exudate.

tunica propria revealed more mature diffuse connective tissue cells in large numbers throughout, but especially in septal areas, and more fibrous strands of connective tissue. The capillaries were dilated throughout.

Dog 3.—The right side of the nose was ionized, and the animal was killed in four weeks. The epithelium on the right side was higher than that on the unionized side and intact, with the usual number of goblet cells. Cilia were present. The tunica propria showed thickening by broadening of the connective tissue strands

of the stroma, especially adjacent to the periosteum, and of the supporting tissue of the glands and by moderate to marked connective tissue cell infiltration. The walls of the blood vessels were thickened.

Dog 4.—The left side of the nose was ionized, and the animal was killed in seven weeks. The epithelium showed no appreciable change from normal on either side. In the tunica propria there was noticeable thickening with marked connective tissue cell infiltration, in most places with fibrosis, especially adjacent to the periosteum. Nerve trunks were seen midway between the epithelium and the bone. Smaller trunks were more superficial in the glandular layer. Fibrils were

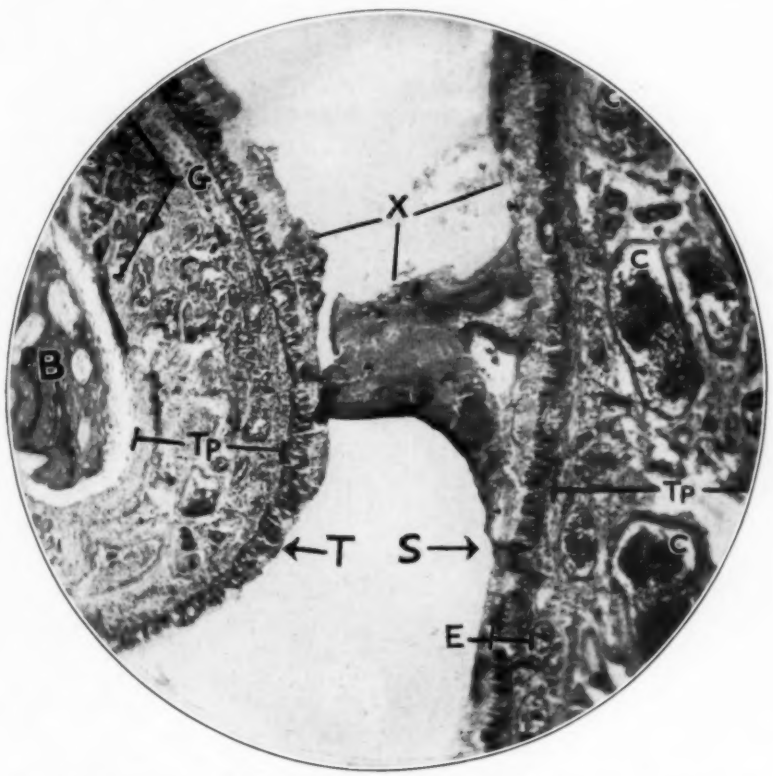

Fig. 2.—Mucosa of the septum and adjacent turbinate eighteen hours after ionization. The exudate is serofibrinous. The epithelium is swollen and partially disintegrated. The tunica propria is markedly edematous and infiltrated with young connective tissue cells in the subepithelial zones. The capillaries are greatly dilated, some being ruptured. The glands are edematous.

noted everywhere, even in the epithelium in places and especially along the periphery of the walls of blood vessels. No degeneration of the axons or myelin sheaths was discernible when the sections were stained with Ranson's pyridine silver stain for nerve tissue. In the glands most of the cells were swollen to the point of obliteration of the lumen, especially in areas of the most intense cellular infiltration. The walls of the capillaries showed some thickening.

Dog 5.—The frontal sinuses were prepared as in the previous experiments, a positive electrode being inserted in each. The animal was killed in seven weeks. The epithelium showed normal and higher than normal ciliated cells and large numbers of goblet cells except over the windows, where there was a nonciliated, low cuboidal type of cell. The tunica propria showed marked fibrosis in most places, either with or without thickening. In some areas there was less fibrosis; frequently there were areas of round cell infiltration. The capillaries were not changed. The periosteum showed moderate to marked thickening.

Fig. 3.—Mucosa of the septum and exudate shown in figure 2; high power. The exudate is closely attached to the epithelium, which is swollen and partially disintegrated. The tunica propria is markedly edematous and infiltrated with young connective tissue cells in the subepithelial zones. The capillaries are greatly dilated, being partially ruptured. The glands are edematous.

Dog 6.—Each frontal sinus was ionized with a positive electrode, and the animal was killed in twelve weeks. The left sinus was opaque, and the right sinus clear. The left sinus revealed bony trabeculae throughout except for a small rudimentary sinus cavity in the center that was loosely lined with a delicate membrane containing a few capillaries with either thin or thick walls and covered with a single layer of pale-staining, low cuboidal epithelium. Other slides showed an ill defined cavity filled with fibrinous tissue, more concentrated at the margins

of the irregular bony trabeculae. There was no epithelium. There were many thin-walled capillaries of various sizes.

The epithelium of the right sinus showed high columnar ciliated cells and a large number of goblet cells. There were low cuboidal almost squamous cells in places interspersed with nonciliated connective tissue cells over an area of bony regeneration of the window and a similar type of cell in other areas. The tunica propria was thickened, edematous in places and infiltrated with large numbers of round and connective tissue cells. It was fibrosed and contracted in other places. Large numbers of newly formed capillaries and blood spaces of all sizes were present.

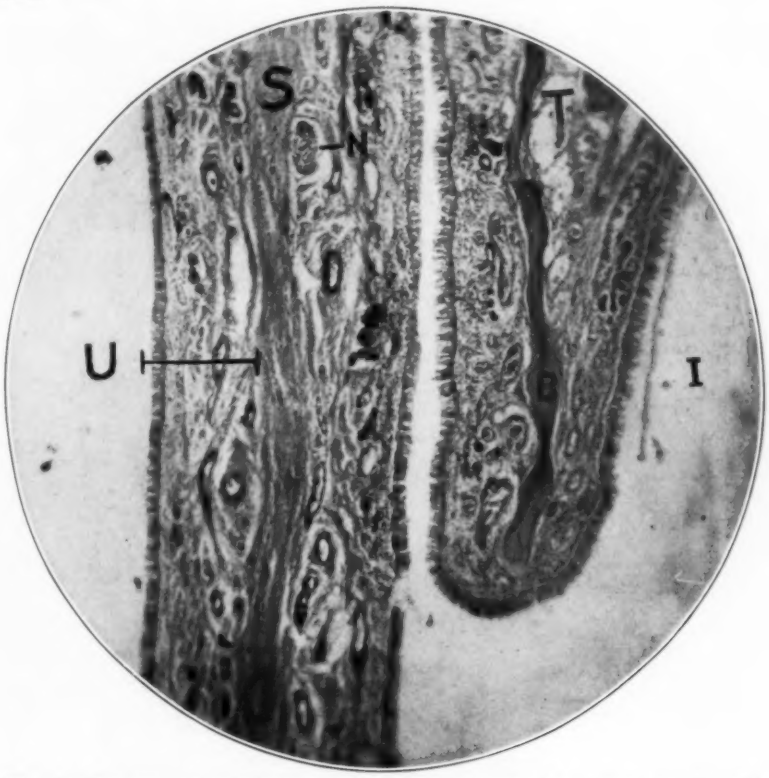

Fig. 4.—Septum and turbinate two weeks after ionization. The septal cartilage is fibrosed. On the unionized side the epithelium and tunica propria are normal. On the ionized side the epithelium is normal and cuboidal. The tunica propria is thickened and shows early fibrosis and generalized marked round cell and young connective tissue cell infiltration in subepithelial zones. In the turbinate the epithelium is slightly thickened. The condition of the tunica propria is similar to that of the septum.

COMMENT

From the accompanying table the progressive nature of the fibrosis of the tunica propria of the mucosa of the nose, as well as of that of the frontal sinuses, is plainly evident. The steps of connective tissue recon-

struction can readily be followed from the time of irritation of the tunica propria by the ionization, which caused the laying down of fibrin, and the entrance of the very young connective tissue cell which became the fibroblast and then the mature connective tissue cell (figs. 2 to 7). Finally, there is seen the agglomeration of these cells to form fibrous tissue, which is a definite and permanent structure (fig. 8). This progression was found to be gradual but unmistakable, starting in the dog killed a few hours after ionization and progressing through five

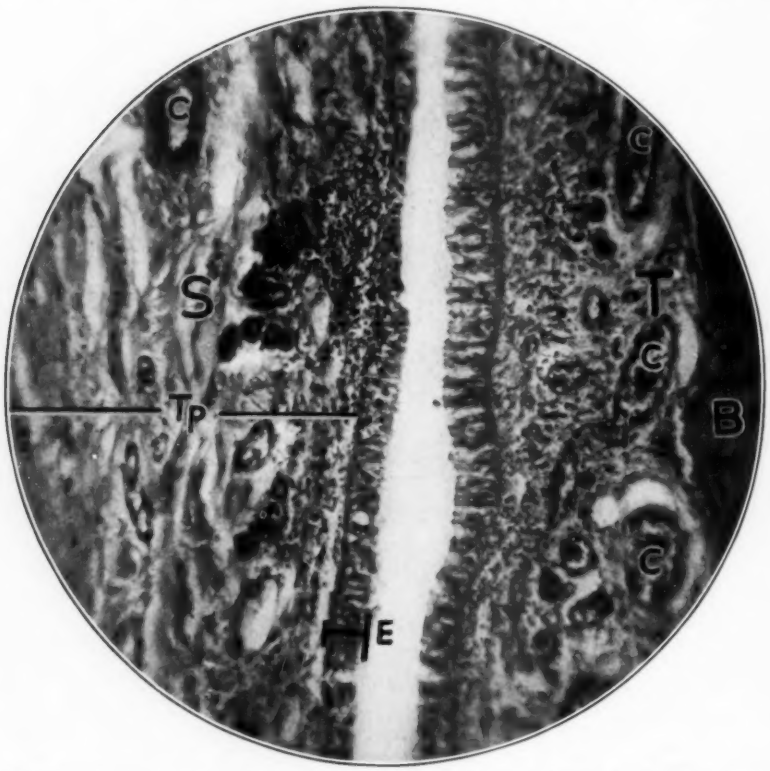

Fig. 5.—Ionized side of the septum and turbinate shown in figure 4; high power. The lower two thirds of the epithelium is normal, but the upper third is cuboidal. The tunica propria shows marked round and young connective tissue cell infiltration in subepithelial zones and thickening of the connective tissue stroma in deeper portions. The epithelium of the turbinate is thickened and shows numbers of goblet cells. Cellular infiltration is marked. More advanced fibrosis of the tunica propria may be noted. The walls of the capillaries are slightly thickened.

dogs killed at intervals, to become fully established in the dog killed twelve weeks after ionization.

The frontal sinuses were again used in these experiments in order to complete the observations made last year, as the destructive changes

noted in the mucosa immediately after ionization prognosticated reparative changes of a character deleterious to the proper functioning of the mucosa. The reaction of the connective tissue of the tunica propria of the sinuses was identical in intensity with that of the nasal mucosa (figs. 6 and 7) and in direct proportion to the amount of ionization and to the length of time that the dog was permitted to live. The most intense reaction to irritation occurred in the left sinus of the dog killed after twelve weeks, in which practically the entire area of the sinus

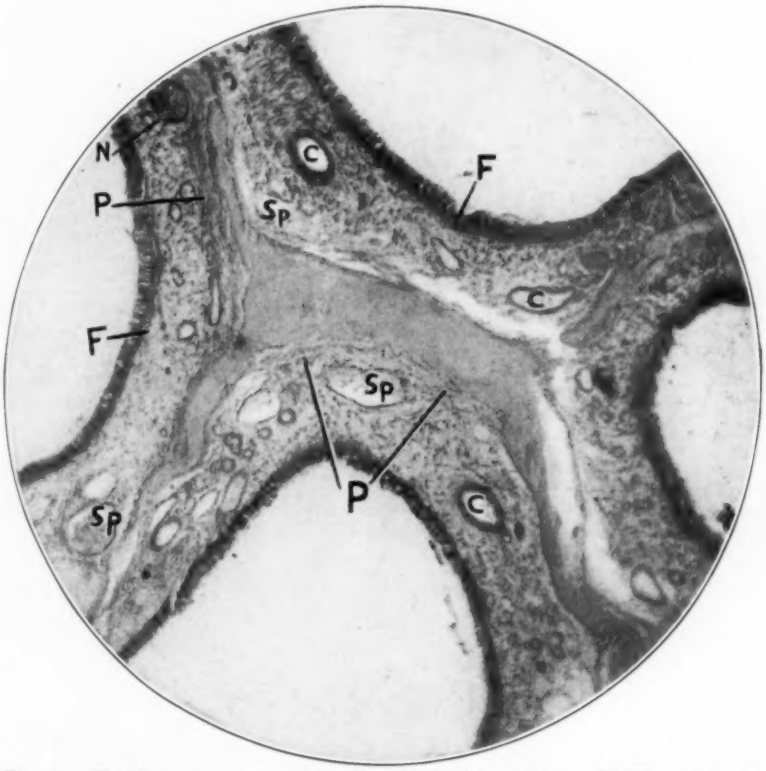

Fig. 6.—Turbinate seven weeks after ionization. The epithelium is normal. The tunica propria is thickened and markedly infiltrated with older connective tissue cells. More advanced fibrosis is present immediately underneath the epithelium and adjacent to the thickened periosteum. The walls of the capillaries are thickened. Three blood spaces are indicated.

cavity was filled with trabeculae of newly formed bone, leaving no true sinus cavity but a space partially filled with fibrin undergoing fibrosis and lined in places with an indifferent type of epithelium. The tissue underneath this epithelium and between the bony trabeculae consisted of a delicate granulation tissue (fig. 9). In the tunica propria of the right sinus of the same dog there appeared to be an increase in the number

of capillaries, which seemed to take place by budding and branching from the original capillaries, as a reaction to the irritation. This modification of the capillaries was not noted in the nasal mucosa, the only change being a slight thickening of the vessel walls. The fibrosis was most marked immediately underneath the epithelium and in many places formed a solid band between the epithelium and the bone (figs. 8 and 9).

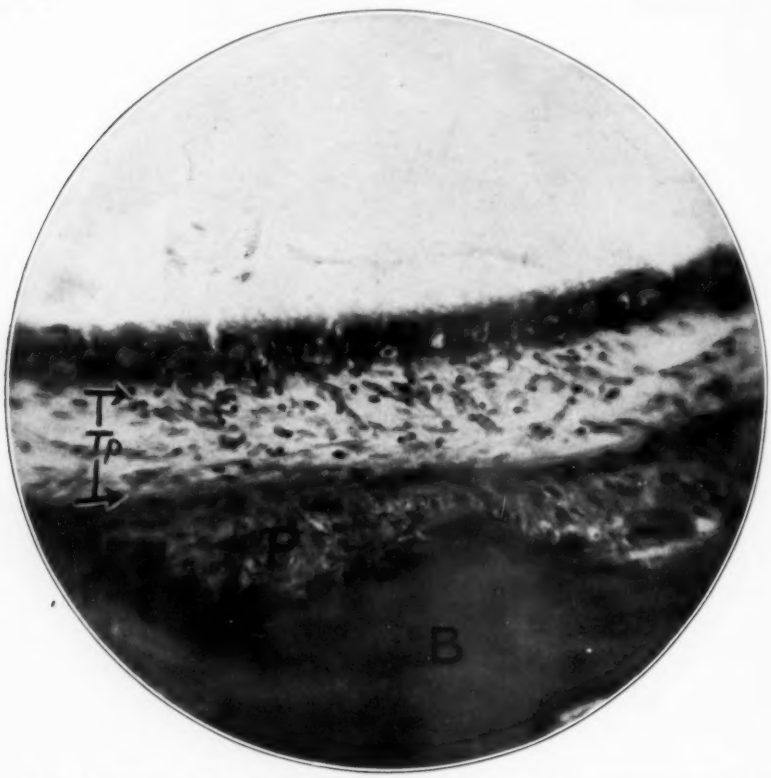

Fig. 7.—Mucosa of the frontal sinus seven weeks after ionization. The epithelium is thickened and infiltrated with young connective tissue cells. Goblet cells are not present. The tunica propria is greatly thickened and markedly infiltrated with older connective tissue cells especially adjacent to the thickened periosteum.

The epithelial reaction in the nose consisted principally of a granular degeneration of the nucleus and protoplasm of the individual cells and a disintegration and sloughing of the cells singly and in large clumps up to eighteen hours. This epithelium appeared to have regenerated and returned to normal after two weeks. The surface was covered with a thick fibrinous exudate in which the sloughed epithelial cells were incorporated (figs. 2 and 3). The epithelium of the frontal sinuses,

which was presumed to be more or less completely destroyed by the ionization, had regenerated to its normal state, namely, a high columnar ciliated type containing many goblet cells, except over the areas of the healed windows and several other smaller areas, where it was non-ciliated, low cuboidal and almost squamous, interspersed in places with connective tissue cells (figs. 7 and 9). This suggests that after the epithelium of a sinus is destroyed it does not regenerate altogether normally, even though normal epithelium is present. It also points to

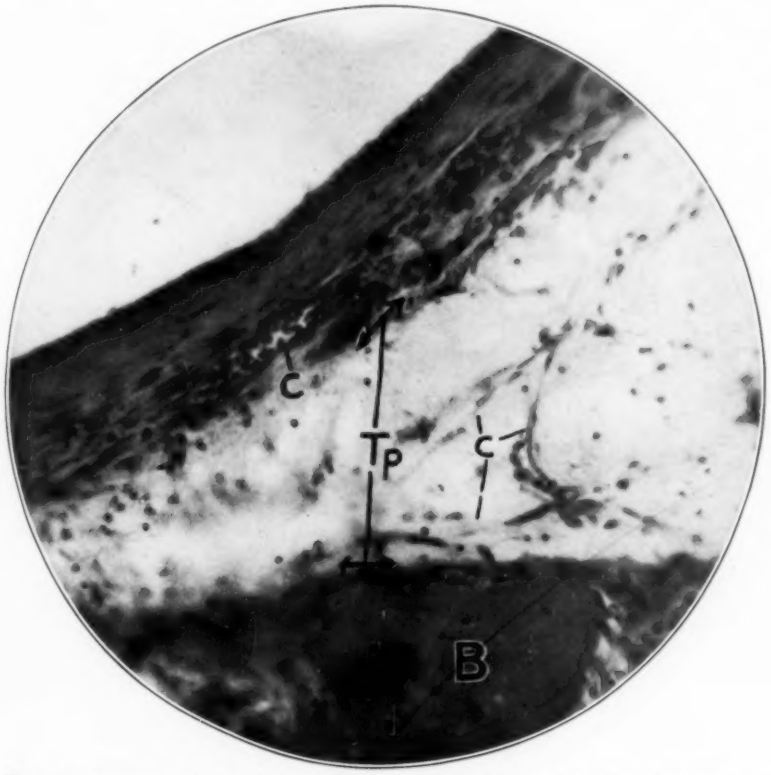

Fig. 8.—Mucosa of the right frontal sinus twelve weeks after ionization. In the epithelium are low cuboidal nonciliated cells instead of the normal columnar ciliated type. The tunica propria is markedly fibrosed immediately underneath the epithelium and edematous, with many newly formed blood capillaries in deeper portions. The periosteum is thickened.

the fact that, though a sinus in which the mucosa has been destroyed may be lined with partly normal epithelium, the subepithelial tissue is not normal since excessive fibrosis occurs in the reaction of repair (figs. 7 to 9).

A desire to ascertain whether or not ionization affects the nerves of the nasal mucosa prompted the making of special stains for nerve tissue

(Ranson's pyridine silver) of a series of sections from the tissue of the dog killed after seven weeks. The larger nerve trunks were located midway between the epithelium and the bone; the smaller trunks were situated more superficially in the glandular layer and immediately beneath the epithelium, and the fibrils were arranged in a more or less irregular network throughout the entire mucosa and along the outer coat of the blood vessels and capillaries. Occasional fibrils could be traced into the epithelial layer. No degeneration either of the axons or of the myelin sheaths could be seen.

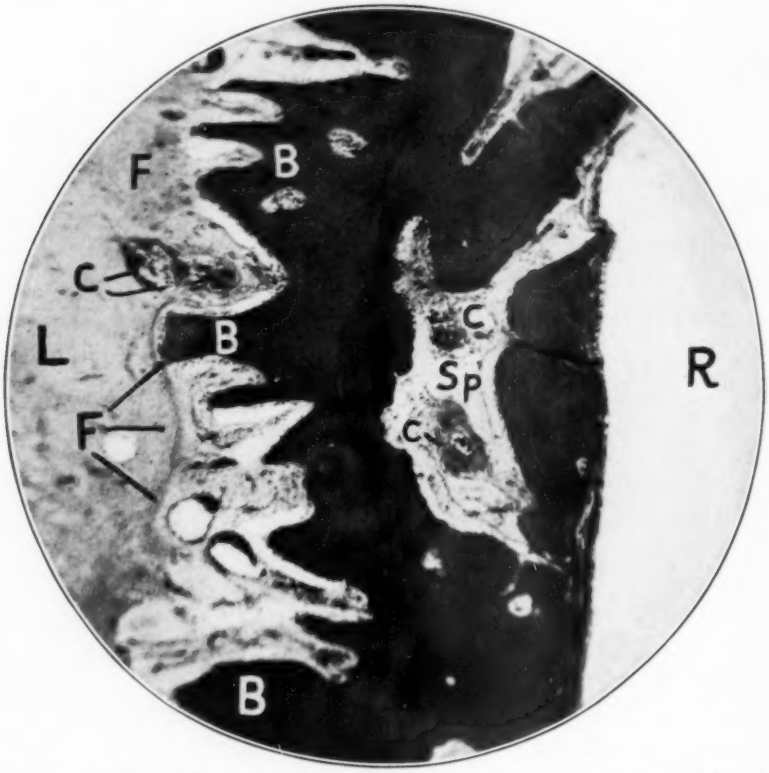

Fig. 9.—Septum between the frontal sinuses twelve weeks after ionization. The epithelium of the right sinus is normal and bound closely to the bone by a dense, fibrous tunica propria. The bony trabeculae extend into the cavity of the left sinus, which is filled with young fibrous granulation tissue. Other sections show the entire sinus cavity traversed by similar bony trabeculae. There is considerable fibrous granulation tissue. The space in the bone is partly filled with fibrous tissue.

SUMMARY

A study has been made of the effects on the mucosa of the nose and frontal sinuses of dogs following ionization, the immediate widespread destructive changes and the readjustment of these delicate tissues

characterized by a progressive accumulation of connective tissue in the tunica propria, as evidenced in dogs killed eighteen hours, two weeks, four weeks, seven weeks and twelve weeks, respectively, after ionization. The changes observed in the mucosa and bone of the frontal sinus are further corroboration of the reaction of such tissues to extreme irritation.

From a clinical standpoint, however, interest is centered on the changes in the mucosa of the nose. Should generalized fibrosis of the nasal mucosa be considered as an optimum state for the proper functioning of that mucosa? Increased and excessive fibrosis means depletion of the blood supply to these structures and further fibrosis; it means atrophy of the glands due to compression as well as depression of secretions and compression of nerves, with the imminent probability of giving rise to nasal pains, hyperesthesia, neuritis and headache of a more or less intractable nature, even though there is apparently no damage to the nerve structures themselves.

All of these changes would not be expected to take place within a few months in the nose of a human being which has been ionized, as the individual reaction is too variable as to time, but there is ample reason to fear that within a comparatively short time a condition would be brought about which might be aptly termed a premature nasopause.

CONCLUSIONS

1. Ionization of the nose of dogs with a solution of zinc sulphate caused a fibrosis of the subepithelial tissues which was seen to be progressively more marked and well established in the animals killed at intervals of from eighteen hours to seven weeks following ionization.

2. Ionization of the frontal sinuses caused a similar fibrosis in dogs killed at seven and twelve weeks, respectively; marked hyperplastic changes in the bone occurred in the dog killed at twelve weeks.

3. The epithelial changes in the nose consisted of primary destruction and later regeneration practically to normal, while in the frontal sinuses there occurred an eventual transition to a cuboidal type of cell over the areas of greatest destruction.

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DISEASE OF THE HIP COMPLICATING OTOGENIC SEPSIS

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Within the last few years I have had an opportunity to observe several cases of otogenic sepsis with suppurative complications in the hip. The relatively few reports in otologic literature of such an important, rather frequent and, at times, serious complication prompted me to discuss this subject at this time. The significance of suppurative conditions in the hip in cases of diseases of the ear can be seen when one realizes that they may occur without an apparent previous thrombosis of the lateral sinus or internal jugular vein, that the onset may be incipient, that progress may be rapid and that a delay in diagnosis may lead to serious consequences.

Otogenic sepsis may occur without sinus thrombosis. This type will be considered in this paper. Schwartze [1] in 1885 expressed the opinion that this type was caused by osteophlebitis of the mastoid bone. In 1902 Körner [2] described it as a clinical entity occurring chiefly in children and growing adults as a complication of acute otitis media or mastoiditis with no thrombosis of the sinus and with metastases to the joints, bursae, muscles and other organs, usually having a favorable prognosis. Mygind [3] considered otogenic sepsis to be a pathologic entity which perhaps with few exceptions is caused by thrombophlebitis of the sigmoid sinus, jugular bulb or both. One cannot say definitely that a thrombus does not occur in these cases, for a mural or parietal clot may be present and still permit free passage of blood. The pathologic process can be determined only by biopsy of the sigmoid sinus and jugular bulb to exclude their presence.

Metastases are a frequent complication of otogenic sepsis. Körner [2] considered their development an essential point in the clinical picture. Mygind [4] reported 9 cases in which there was no thrombosis and recovery

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Presented as a candidate's thesis to the Chicago Laryngological and Otological Society, October 1934.

1. Schwartze, H., cited by Seydell, E. M.: Otitic Pyemia Without Sinus Thrombosis, Ann. Otol., Rhin. & Laryng. **31**:862, 1922.

2. Körner, Otto: Die otitischen Erkrankungen des Hirns, der Hirnhäute und der Blutleiter, Wiesbaden, J. F. Bergmann, 1902, p. 93.

3. Mygind, Holger: Contribution to the Etiology and Pathogenesis of Otogenic Sinus Phlebitis, J. Laryng., Rhin. & Otol. **31**:34, 1916.

4. Mygind, S. H.: Treatment of Otogenic Sepsis and Sinus Thrombosis, Acta oto-laryng. **16**:474, 1931.

occurred, in 7 of which there were complications. Of these 7, 5 occurred in children who had metastases to the joints and muscles. Mygind also reported metastases in 41.6 per cent of 93 cases of sinus thrombosis following conservative treatment. For comparison, he cited the figures of Brieger, who reported metastases in 58 per cent of his cases, and of Fieandt and Haymann, who reported an incidence of 39 and 34 per cent, respectively.

The localization of these metastases is varied, involving the lungs, joints, muscles, mucosa and other organs. To determine the incidence of involvement of the joints, especially in the hip, is difficult because of the paucity of reports and data. Atkins [5] in reviewing the reports of 40 cases of thrombosis of the lateral sinus found that metastases mainly to the joints occurred in 40 per cent. Boies,[6] in a review of the reports of 184 cases of lateral sinus thrombosis, noted 68 cases in which complications occurred, in 11 of which there was suppurative involvement of the joints. Guthrie and Middleton [7] stated that the hip is the most frequently involved area when metastatic arthritis complicates thrombosis of the lateral sinus. Friesner [8] found in his cases that the hip was the site of election of articular involvement secondary to otitic bacteremia in children. Cooperman [9] observed 6 cases of acute metastatic pyogenic arthritis of the hip in children ranging from 5 to 13 years of age, mono-articular in all instances, in 2 of which the condition occurred in the course of a mastoidectomy. Sneed [10] stated that he had observed several cases of infection of the hip complicating mastoiditis with resection of the jugular vein.

There have been a few cases reported in the otologic literature of otogenic sepsis with complications in the hip. Kiehle [11] reported a case of a boy, aged 8 years, with metastases to both hips requiring incision and drainage. Subsequent erosion of the acetabular rims left the

5. Atkins, R. T.: Forty Cases of Lateral Sinus Thrombosis, New York State J. Med. **24**:885 (Oct.) 1924.

6. Boies, L. R.: Lateral Sinus Thrombosis: A Review of One Hundred and Eighty-Four Cases with Special Reference to the Postoperative Type, Ann. Otol., Rhin. & Laryng. **41**:227, 1932.

7. Guthrie, D., and Middleton, D. S.: Septic Thrombosis of the Lateral Sinus in Children, Brit. M. J. **2**:140 (July 25) 1931.

8. Friesner, I.: Infections of the Middle Ear: Acute Systemic Infections from the Ear, Arch. Otolaryng. **14**:257 (Sept.) 1931.

9. Cooperman, M. B.: Acute Pyogenic Arthritis of the Hip Joint, Am. J. Dis. Child. **31**:183 (Feb.) 1926.

10. Sneed, W. L.: Orthopedics in Childhood, Philadelphia, J. B. Lippincott Company, 1931, p. 116.

11. Kiehle, F. A.: Acute Suppurative Otitis Media Causing Septic Arthritis Without Observable Symptoms of Intervening Mastoiditis or of Involvement of the Lateral Sinus, Ann. Otol., Rhin. & Laryng. **35**:884, 1926.

boy noticeably lame but able to walk without crutches. Guthrie and Middleton [7] reported a similar case of an 8 year old girl who had seven operations with final recovery after a prolonged illness. Bony ankylosis of the right hip joint in good unctional position resulted, with comparatively little shortening. McDaniel [12] had a case of thrombosis of the jugular bulb with multiple metastases, one of which involved the right hip, resulting in pathologic dislocation with subsequent ankylosis. Salinger [13] observed a case of multiple metastases complicating thrombosis of the lateral sinus. The left hip was drained, with subsequent complete recovery. Undoubtedly these reports represent a small number of a type of complication not uncommon to the experienced otologist.

REPORT OF CASES

The following reports are of cases of otogenic sepsis without apparent thrombosis of the lateral sinus complicated by metastasis to the hip:

CASE 1.—C. P., a boy 7 years of age, the patient of Dr. A. W. Rambar, had otitis media on the right side with a temperature of 102 F. Paracentesis was required two days after the onset. Pain, low grade fever and tenderness over the mastoid persisted in spite of a profuse seropurulent discharge. On the fourth day the characteristic lesions of measles developed. The patient was removed to the hospital on the eighth day with a complaint of exquisite tenderness over the mastoid area. A profuse pulsating discharge was present in the right external auditory canal. The temperature was from 101 to 102 F. Roentgenograms of the mastoid processes revealed good pneumatization with haziness of the cells on the right side but no evidence of destruction of the bone. While the patient was under observation the temperature rose to 104 and 105 F. on the thirteenth and fourteenth day, respectively. A simple mastoidectomy was performed on the right side with the patient under ethylene anesthesia. A large mastoid process was found, with cells broken down and a small amount of free pus. The pathologic process had exposed the lateral sinus and dura of the middle fossa. Both appeared normal. A culture taken from the mastoid secretions revealed Streptococcus haemolyticus.

The temperature, taken rectally, remained of a septic type, ranging from 99 to 106 F. daily, with slight chilly sensations. A blood culture made the day following the operation was positive for Str. haemolyticus within twenty-four hours. A complete examination, including roentgen examination of the chest and spinal puncture, yielded essentially negative findings. On the second day following the mastoidectmy the right internal jugular vein was exposed and found full; nevertheless, it was ligated, and the mastoid wound was reopened. The lateral sinus was exposed farther, both toward the torcular end and toward the jugular bulb, and appeared normal. When the sinus was opened, free bleeding occurred from both ends. A transfusion of 250 cc. of whole blood was immediately given. The following day the patient was drowsy and irrational at times. The temperature remained high. For the next few days, the patient's condition remaining the

12. McDaniel, F. C.: Jugular Bulb Thrombosis, Multiple Abscesses, Recovery, Laryngoscope **37**:429, 1927.

13. Salinger, S.: Personal communication to the author.

same, a number of small transfusions of whole blood were given. On one occasion an intravenous injection of antistreptococcus serum was given. A reaction to the serum manifested chiefly by generalized urticaria appeared.

A week after the mastoidectomy and three weeks after the onset of the infection in the ear the boy complained of pain in the upper part of the left thigh and left elbow. The left leg was held in adduction and flexion, and movement caused considerable pain. There was diffuse tenderness over the joint. No swelling or fulness was noted. The temperature on that day and for several days following was somewhat higher. Roentgen examination of the region of the left hip failed to reveal a pathologic process. A slight fulness posteriorly over the left hip was noticed a week later, and on the tenth day following the onset of the pain the left hip was aspirated. The needle appeared to fall into a large cavity, apparently around the joint, from which pus was obtained. An incision was made, from 6 to 8 ounces (177 to 206.5 cc.) of pus was evacuated, and rubber drains were inserted. A culture of the pus revealed a hemolytic streptococcus. On the third day the drainage practically ceased and the temperature was almost normal. Two days later roentgenograms of the region of the hip revealed a normal picture, and the drains were removed, permitting the wound to close. Passive and active motion were undertaken immediately. Two months after the onset of the illness the patient was discharged with full, unlimited movement of the left hip. The white blood count during the illness ranged between 25,000 and 30,000, and the urine showed evidence of mild nephritis.

This was a case of otogenic sepsis with no apparent thrombosis of the lateral sinus, complicated by measles, a metastatic abscess to the left hip, a reaction to serum and mild nephritis. The organism obtained from the ear, blood and hip was Str. haemolyticus. The early appearance of swelling about the hip and negative roentgen findings, with immediate and complete recovery following incision and drainage, speak more for an extra-articular rather than an intra-articular abscess.

Case 2.—R. S., a youth 15 years of age, a patient of Dr. A. Sinaiko with whom I consulted, had pain behind the right ear for four days, requiring paracentesis, with a temperature of 102.4 F. the day previous to examination. A mastoidectomy on the right side had been carried out ten years before. On the fifth day of the present illness a fluctuant swelling appeared over the right mastoid area, which was incised and drained. The patient improved for a day or two, and then a septic fever developed, the temperature ranging from 99.9 to 104.5 F., with chills. This condition continued for one week. A mastoidectomy was carried out, with exposure of the lateral sinus, which was covered with a few granulations. The sinus was not opened. There was improvement for a few days, and then chills and fever recurred. About a week later the mastoidectomy wound was reopened, and the lateral sinus was punctured, blood being obtained from the upper end but none from below. The internal jugular vein was ligated, and the sinus was then opened. No thrombus was found. There was some improvement for a few days, and then the sepsis recurred. Blood cultures showed a staphylococcus. Four weeks later the patient began to complain of pain in the region of the left hip. The thigh became slightly swollen, with some tenderness and slight induration. Roentgen examination gave negative results. A week later the patient was given a transfusion of blood, and the swelling over the hip was incised. A

large quantity of pus was evacuated. Recovery from then on was gradual but uneventful, leaving no deformity. Subsequent roentgenograms of the joint showed no deviation from the normal.

This was a case of otogenic sepsis followed by an abscess of the left hip. No thrombus was demonstrable in the lateral sinus. There appears to have been an extra-articular abscess in view of the definite and immediate relief of symptoms following incision and drainage with complete recovery of all motion.

Case 3.—S. W., a girl 4 years old, a patient of Dr. Robert Sonnenschein, had a discharge from the right ear for about three and one-half weeks, with severe pain and headache toward the end of this period. The temperature was high during this time. There were slight swelling, redness and considerable tenderness over the region of the right mastoid process. A simple mastoidectomy was performed, and a small subperiosteal abscess was found. The mastoid cells were broken down, and free pus was present in the region of the antrum. The lateral sinus was exposed, was found to be somewhat discolored and was not opened. The temperature became septic, at times rising to 104 F. during the next two weeks.

General medical examination gave negative results. The Tobey-Ayer test revealed no evidence of occlusion of either the jugular vein or the lateral sinus. Two and one-half weeks after the mastoidectomy was performed the patient had a severe chill lasting for fifteen minutes, followed by a temperature of 106 F. The mastoidectomy wound was reopened, and the lateral sinus was found to be covered with granulations. The sinus was opened, and free bleeding was obtained from both ends. The internal jugular vein was ligated and cut. A transfusion of blood was given immediately after the operation. The patient remained unconscious for several hours, with a rapid, feeble pulse, dilated pupils, a Babinski sign on the left, ankle clonus, the Kernig phenomenon and considerable restlessness. The clinical picture was that of shock with some intracranial pathologic process. A spinal puncture was carried out, and the fluid was found to be under greatly increased pressure. A positive reaction for globulin was present. The fluid was slightly cloudy, containing 100 cells per cubic millimeter, 50 per cent of which were polymorphonuclear leukocytes. Two hours later there was no Kernig or Babinski sign. The following day the patient was greatly improved, and the temperature gradually became normal.

Several days later, a month after the mastoidectomy and two months after the onset of the infection in the ear, the patient complained of pain in the right knee. The temperature rose to 105.2 F. The right thigh was held flexed on the hip and in adduction. There was extreme tenderness in the region of the greater trochanter. A surgeon advised immobilization and watchful expectancy and made a diagnosis of possible arthritis of the right hip joint or osteomyelitis of the right femur. Roentgen examination revealed no change in the joint except a moderate degree of rarefaction just below the femoral epiphysis. There was a shadow over the entire area caused by swelling of the soft tissues about the hip. The temperature remained low, and the hip seemed less painful. Ten days later another roentgenogram showed the condition to be unchanged. An exploratory operation disclosed considerable pus, and drainage was instituted. This was three weeks after the onset of pain. Two weeks later roentgenograms revealed complete dislocation of the head of the femur from the acetabulum, with slight irregularity,

rarefaction and erosion of the head in the intertrochanteric area. There was spontaneous dislocation posteriorly, accompanied by acute synovitis and effusion of considerable fluid. Several days later the dislocated head of the right femur was reduced under fluoroscopic guidance, and a body cast was applied. Ten weeks after the mastoidectomy measles supervened.

Another roentgen examination two weeks later again showed complete dislocation of the right hip with rarefaction of the head and neck of the femur. The acetabulum appeared partially destroyed. The wound was reopened to allow for free drainage and a body cast reapplied, holding the leg in abduction, extension and slight internal rotation. Subsequent roentgenograms showed osteomyelitis of the right hip joint. The wound drained freely and constantly for many weeks. Several weeks after this a collection of pus in the soft tissues on the medial posterior aspect of the right thigh was evacuated. A cast was applied to permit ankylosis in the elective functional position. The patient was discharged three months later after a nine months' stay in the hospital and approximately ten months after the onset of her illness, with ankylosis of the right hip joint and considerable shortening of the limb.

This was a case of otogenic sepsis with no definite evidence of thrombosis of the lateral sinus, complicated by shock and by what appeared to be cerebral edema following ligation of the right internal jugular vein and obliteration of the right lateral sinus. A metastatic infection in the right hip joint appeared three weeks after the mastoidectomy, resulting in femoral epiphysitis, osteomyelitis, suppurative arthritis, spontaneous dislocation and complete destruction of the head of the femur, with subsequent ankylosis and shortening. Drainage in this case was not instituted until three weeks after the onset of pain in the hip, though early roentgen examination revealed rarefaction of the epiphysis of the femur and an exudate in the surrounding soft tissues.

Case 4.—C. B., a boy 14 years of age, was admitted to the Michael Reese Hospital in the service of Dr. S. J. Pearlman with a history of pain in the left ear for six days. Spontaneous discharge, high fever and headache had been present for the past three days. He had several chills on the day of admission to the hospital. Examination gave essentially negative results except for a profuse discharge from the ear, exquisite tenderness over the mastoid area and cervical adenopathy on the left side. Spinal puncture was carried out because of drowsiness and headache, but the fluid showed no marked deviation from the normal. Roentgen examination of the mastoid process revealed no apparent cellular destruction. The temperature ranged between 104 and 106 F. A simple mastoidectomy on the left side was performed with the patient under ethylene anesthesia. The cells in the regions of the antrum and tip were soft and contained pus. The lateral sinus was exposed and inadvertently opened. Bleeding was free. A blood culture showed Str. haemolyticus. The temperature remained persistently high. A few days later the left internal jugular vein was ligated. The temperature dropped slightly, and the blood culture became negative.

Six days after the mastoidectomy the patient complained of pain in the regions of the left hip and knee. A dark blue area was found over the left buttock, probably embolic. Both legs were held stiff, with definite pain and limited motion. The swelling over the buttock became larger and subsequently broke down. Three

days later there developed a swelling of the back of the left hand. This was incised, and 2 ounces (59 cc.) of pus was obtained. During the next four weeks the pain in both lower extremities continued. The legs were held in extension, and movement produced pain in both the hips and the knees. Two transfusions of blood were given. Roentgen examination carried out four weeks after the onset of pain showed a density over the articular surfaces of both knees and along the heads of the femurs. The findings were suggestive of probable destructive arthritis. A body cast was applied. The temperature became normal. Two months later roentgen examination disclosed bilateral bony ankylosis of the hips. The patient was discharged with bony ankylosis of both hip joints in good functional position. The knees were not involved (fig. 1).

This was a case of otogenic sepsis with bilateral metastatic disease of the hip joints resulting in bony ankylosis of each hip. Roentgen examination and therapy were not instituted until four weeks after the onset of pain in the involved joints.

Fig. 1.—Roentgenogram of both hip joints and the pelvis of the patient in case 4, showing bilateral ankylosis of the hip joints.

COMMENT

The complications in the hip secondary to otogenic sepsis are metastatic pyogenic infections carried by way of the blood stream. The infection may be either single or multiple. Such complications are by far more prevalent in children than in adults. They may be sequelae to the acute infectious diseases as well as to local suppurative foci, such as otitis media, pyelitis and mastoiditis. Almost every known pyogenic organism has been described in association with these lesions. The most common are the cocci, especially the staphylococci, which are the most virulent, followed closely in this respect by the streptococci.

The metastases may be either extra-articular or intra-articular. The extra-articular infections include suppurative inflammations of the subcutaneous tissues, fascia and muscles around the hip joint. The

superficial metastases need not be considered here, as they offer little difficulty in diagnosis and treatment. The deep-seated infections, namely, those of the deep musculature and fascia around the hip joint, are very important. These may produce symptoms similar to those of infection of the joint proper, frequently making an early diagnosis very difficult. The hematogenous infection usually produces a circumscribed suppurative inflammation in one or several of the muscles. There is beginning myositis, with painful swelling of the muscles resulting in complete loss of function. The muscles become enlarged and hard. Their boundaries are obliterated. This hard, painful swelling develops suddenly and gradually softens, giving evidence of an abscess. The external evidence is not present early, because of the deep-seated location of the infection, and may not appear for a week after the onset of symptoms. During this period the differentiation from true involvement of the hip joint is difficult. Even when external swelling appears, it may be confused with the brawny induration and thickening of the soft parts around the joint frequently found in purulent infections of the hip joint.

The intra-articular complications may start in the joint from involvement of the capsule and synovial membrane or may be secondary to hematogenous osteomyelitis of the articular surfaces, the head and neck of the femur or the epiphysis of the upper end of the femur. The infection may be caused by deposits of virulent bacteria (mycotic emboli) in the capillaries of the synovial membrane or in the bone marrow. One can easily understand how osteomyelitis of the head or neck of the femur may lead to arthritis of the hip joint, since the whole of the epiphyseal line and the proximal part of the diaphysis are included within the capsule of the joint. The rapidity with which the hip joint may become secondarily involved has been described by Speed [14] in a discussion of septic femoral epiphysitis. The hip joint is included early, the process taking place in a few hours. The infection involves the epiphyseal area and spreads along the cartilage plate, attacking much of the blood supply by thrombosis or direct contamination.

The localization of metastatic infection in the hip joint is aided by the rich blood supply and possible associated trauma. The character of the blood supply plus even slight trauma, such as active motion or weight bearing, in the presence of circulating toxemia invites infectious infarcts or pyemic plugs into this area, with a consequent disease process. Kolodny [15] described four groups of blood vessels supplying the head and neck of the femur in the child and new-born infant (figs. 2 and 3).

14. Speed, Kellogg: Acute Epiphysitis at the Upper End of the Femur: Pathology and Treatment, South. M. J. **21**:208 (March) 1928.

15. Kolodny, A.: Blood Supply of the Head of the Femur, J. Bone & Joint Surg. **7**:575 (July) 1925.

Fig. 2.—Roentgenogram of the upper part of the femur of a new-born infant into which red lead was injected, showing the network of vessels and the two main arteries of the round ligament (from Kolodny [15]).

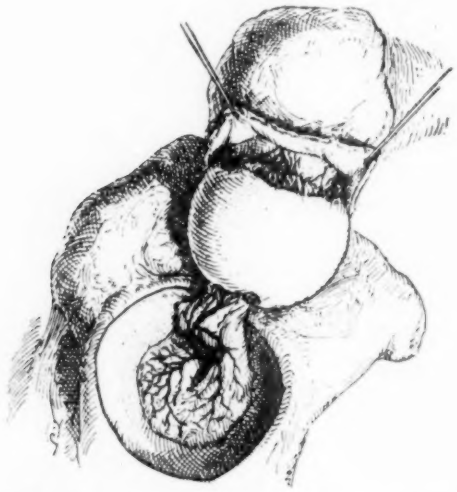

Fig. 3.—Drawing of a specimen from a new-born infant into which dye was injected, showing the blood vessels running along the superior aspect of the neck toward the femoral head and the blood vessels of the round ligament (from Kolodny [15]).

The first group is made up of the blood vessels coming from the diaphysis of the femur and includes the end-branches of the femoral nutrient artery, which may cross the epiphysis to enter the head. The second group is composed of the epiphyseal vessels which enter the head along the edge of the articular surface, one group from above and the other at the insertion of the capsule of the joint on the inferior aspect of the neck. The blood vessels carried by the ligamentum teres and the periosteal blood vessels make up the third and fourth groups, respectively.

The pathologic reaction in the joint is the same whether the bacteria enter by way of the synovial membrane or by rupture into the joint from an acute osteomyelitic process. The reaction consists of three principal types, serous, serofibrinous and purulent, and their transitional forms.

The serous type involves only the synovial membrane and manifests itself by an outpouring of clear fluid into the cavity of the joint and the periarticular tissues. There is usually mild inflammatory congestion of the vessels of the synovial membrane and capsule. In the serofibrinous type the fluid is cloudy, consisting mostly of fibrin, polymorphonuclear leukocytes and red blood cells. The articular cartilage is smooth and unaffected in the early stage but may be covered with a few patches of fibrinous exudate later. Micro-organisms may be present very early in the fluid of the joint. Both the serous and the serofibrinous type are uncommon forms of otogenic metastases.

The purulent form is by far the most common and severe grade of infection of the joints secondary to otogenic sepsis. It may be superficial, involving only the synovia and producing a profuse mucopurulent exudate, or deep, infecting the bony structures. The deep infection is of an invasive, infiltrating character, involving the whole structure of the joint and its surroundings. Considerable fibrin and large numbers of bacteria, polymorphonuclear leukocytes and red blood cells are found in the fluid in the early stages. The exudate usually invades the paraarticular and periarticular tissues, producing brawny induration and thickening of the soft parts around the joint. The cartilage of the joint may become involved very early, leading to serious consequences. When the cartilage becomes infected there is little opportunity for repair because of the lack of blood supply in the articular surfaces. The underlying bone then becomes bared, and purulent osteitis develops in the bony substance rarefied by the disease. Sequestrums may then form. If the tension is released early only slight erosion of the cartilage results. If it is not released early the effusion produces considerable destruction, with rupture of the capsule and dissemination of the purulent material into the surrounding tissues. When destruction has occurred and the bared ends of bone are permitted to come into contact with each

other, various degrees of ankylosis result. Acute purulent arthritis may become a chronic process with periods of acute exacerbation.

The symptoms common to all types of pyogenic disease of the hip are pain in the upper part of the thigh, buttock and groin and tenderness over the affected joint. At times the pain may be entirely referred to the knee on the same side. The limb assumes a characteristic attitude, according to Hart,[16] of flexion of the thigh with adduction and internal rotation. This position is taken very early as a result of the reflex muscle spasm, which is especially prominent in the hip owing to the powerful surrounding musculature. Pain and the fear of pain associated with both active or passive limited movement of the joint is an early and important finding. As the disease progresses, a brawny induration may be felt over the joint due to the invasion of the periarticular and para-articular structures. The induration may later become fluctuant. The constitutional symptoms vary with the severity of the infection. With the purulent form elevated temperature, leukocytosis, prostration and, at times, chills are common findings.

Early diagnosis of suppurative disease of the hip joint is imperative and should be considered a life-saving measure. A delay in diagnosis will result in delayed therapy, which may lead to grave complications. However, early diagnosis may be very difficult. Local findings, such as swelling, fluctuation and heat, commonly noted early in most cases of infection of the joint are relatively late occurrences in cases of disease of the hip joint. This is true because the joint lies deeply in the soft parts. Remote findings must therefore be relied on. These are, essentially, pain, limited motion and deformity. By deformity is meant flexion and adduction, with internal rotation of the affected limb. Aspiration is a valuable aid in the early diagnosis.

Roentgenograms made early, when the diagnosis should be made, usually fail to show involvement of the joint. They may reveal widening of the intra-articular space as a result of effusion, with slight haziness of the outlines of the joint. Roentgenograms should be made of both hips, that of the unaffected side being used for comparison. Later, when destruction has taken place, the change will be seen especially at the points of contact and pressure of the opposing articular surfaces. One should never wait for changes of the bone to appear in the roentgenograms before making a diagnosis. When these changes are present the destruction is usually far advanced. A roentgenogram which fails to show changes should never cause one to rule out the possibility of a pathologic process in the hip joint when definite clinical findings are present.

16. Hart, L.: Attitudes Associated with Diseases About the Hip Joint, Arch. Surg. **22**:463 (March) 1931.

If during the course of otogenic sepsis the patient complains of pain in the hip with an aggravation of the systemic symptoms and there are local signs of tenderness over the hip, early deformity and limited motion, a diagnosis of pyogenic disease of the hip joint should be made and active measures for its verification and treatment be taken at once. If necessary, aspiration from the hip joint should be carried out. Roentgen examination may be of some aid in the early stage of the disease, but negative findings should never cause one to rule out this condition.

The differential diagnosis of metastatic disease of the hip joint during its early stage must include many conditions. The most important from a metastatic point of view are the deep-seated extra-articular infections, acute osteomyelitis of the upper end of the femur or ilium, various types of involvement of the epiphysis of the upper end of the femur (such as acute septic epiphysitis or hemorrhagic, traumatic and transient epiphysitis), traumatic synovitis, tuberculosis of the hip joint and acute inflammatory rheumatism. Of these, I shall consider only the extra-articular, deep-seated infections, because of their rather common occurrence in otogenic sepsis.

These may be very difficult to differentiate from pyogenic disease of the hip joint. The pain and tenderness are localized to the region of the involved hip. The leg is usually held flexed and adducted, owing to reflex spasm of the muscles. There is usually painful and somewhat limited motion of the hip joint. This, however, is not as marked as in intra-articular disease of the joint. Swelling, local heat and fluctuation may not appear until later, when the infection becomes more superficial. The constitutional symptoms are usually less severe. Roentgen examination of the hip joint gives negative results. At times a diffuse haziness may be seen, caused by swelling of the surrounding soft structures. Aspiration may be a valuable aid in differentiating a deep extra-articular infection from an intra-articular involvement. If pus is found in the deep tissues surgical incision and drainage should be instituted at once. The possibility of involvement of the joint or bone should always be considered. Roentgenograms should be made during convalescence to rule out such a possibility.

Treatment for pyogenic infection of the hip varies with the type of involvement. When only clear fluid is found in the cavity of the joint, simple aspiration may be sufficient. This may be repeated if fluid reforms. Immobilization with traction and extension may also be applied. When no fluid is found in the joint simple immobilization with traction and extension may suffice, provided no evidence of active osteomyelitis is present which may require surgical intervention. In the serofibrinous and purulent types of infection incision into the

capsule for drainage, with immobilization, extension and traction, should be instituted at the earliest possible moment. The purpose of incision and drainage in the early stages is to relieve the purulent tension within the cavity as soon as possible, so as to prevent further spread of the infection and destruction of the susceptible articular cartilages. Various methods for this procedure are advocated. Ober [17] suggested posterior arthrotomy because by splitting the muscles a more direct approach is afforded to the joint, with a minimum amount of hemorrhage and rapid effective drainage. Some surgeons advise irrigation fellowing the incision. The object of traction and immobilization is to counteract the protective muscle spasm. This spasm, according to Cooperman,[9] is destructive in its effect on the joint, being one of the principal causes of increased intra-articular tension. Destructive changes, such as deepening and widening of the acetabulum and absorption of the head and neck of the femur, are caused by the tremendous contact pressure of one articular surface against the other, induced by the muscular contraction. Immobilization should be maintained only during the acute state, according to Harris [18] and others. This is usually about two weeks. Early active and passive motion should then be instituted. These voluntary movements may prevent shortening by inhibiting the formation of dense adhesions and enabling the joint to recover perfect function. According to Campbell [19] this can be started as soon as the pain and tenderness have subsided. The drain should be removed as soon as all evidence of acute infection has disappeared. Another group of surgeons advises immediate mobilization following drainage. This is the Willems technic. Caldwell [20] suggested frequent roentgen examinations for a period of from ten to fourteen days after drainage has been instituted, in order to determine the presence or absence of involvement of bone. If destruction of bone is apparent an effort should be made to provide drainage by some other route, away from the hip joint rather than through it. When extensive destruction of bone has taken place, with impending ankylosis, fixation and a cast in a good functional position, namely, for extension and abduction, should be the treatment of choice. This should be followed by mechanical measures, such as the use of braces, for a period of several months, because of a tendency toward flexion and abduction during this interval.

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17. Ober, F. R.: Posterior Arthrotomy of the Hip Joint, J. A. M. A. **83**:1500 (Nov. 8) 1924.

18. Harris, R. I.: Acute Suppurative Arthritis in Children, J. Bone & Joint Surg. **7**:849, 1925.

19. Campbell, W. C.: Orthopedics of Childhood, New York, D. Appleton & Company, 1927, p. 60.

20. Caldwell, G. A.: Acute Suppurative Conditions of the Hip Joint, J. A. M. A. **98**:37 (Jan. 2) 1932.

The sequelae depend on the type of infection, age of the patient, virulence of the organism, delay in diagnosis and therapy. Extra-articular infection rarely produces complications unless it ruptures into the hip joint or invades the bony structures, when it may produce all the sequelae common to these conditions. The usual sequelae of suppurative disease of the hip joint are: first, complete recovery with normal function; second, ankylosis of various types, with the limb in either good or bad functional position depending on the therapy applied, and third, ankylosis with shortening due to extensive destruction of bone and pathologic dislocation. The acute arthritis may also become chronic, followed by frequent exacerbations. The complete course of a neglected or very virulent infection has been described by Speed.[14] He stated that during the acute onset the hip joint becomes distended and the limb seeks a position of flexion and internal rotation. Limited necrosis of the cartilage plate occurs, followed by bursting of the capsule and dissemination of the material in the surrounding tissues. The cartilage of the head of the femur, and sometimes that of the acetabulum, becomes necrotic and dies. The infection may then spread down the diaphysis of the femur or along the pelvic bones or subside. Separation of the head of the femur from the diaphysis may occur at this stage. The pathologic processes of the complications develop at a much slower rate. The head of the femur may become a sequestrum. The pus after bursting through the capsule may burrow along the psoas muscle or posteriorly along the neck of the femur, limited by muscles and fascial layers. The distended hip joint loses its synovial surface by inflammation, resulting in laxity of the capsular covering of the joint. This may lead to a pathologic dislocation of the hip caused by gravity as the patient lies in bed, flexion of the limb and spasm of the flexor and adductor muscles (fig. 4). Formation of new bone begins from the diaphysis or from the eroded surface of the acetabulum or pelvis. Secondary abscesses, septic pneumonia and endocarditis complicate the situation. Sinuses may open spontaneously around the hip. Urinary obstruction from pressure on the urethra may result. Prolonged pressure of the bed may produce decubitus ulcers and osteomyelitis of other parts of the sacrum and ilium. The patient may thus end his days bedridden and in misery. This course fortunately is not a common occurrence and can usually be avoided by early diagnosis and proper therapy. Several of these complications developed in the third case reported.

According to Caldwell,[20] the functional result is excellent as a rule when the process begins in the synovial membrane. Ankylosis and pathologic dislocation make the usual sequel when the primary site of infection is in the intra-articular bony structures. Harris[18] stated that

in those cases in which the joint has been infected from without, as from osteomyelitis of a neighboring focus, there is more tendency to a loss of permanent function than in those in which there is infection from the blood stream. This is particularly true in cases of osteomyelitis, since there exists in the neighborhood an ineradicable source of organisms from which the joint is being continuously reinfected. The infection of the joint cannot be overcome completely until such time as the infection of the bone remains as an isolated focus which can be dealt with by itself. The results also vary with the age of the patient. According to Guthrie and Middleton,[7] in younger children the head and neck of the femur are largely composed of cartilage. This may lead to a dorsal dislocation of the hip. The head and neck then frequently absorb, irrespective of whether the dislocated bone is replaced. This leaves considerable shortening, fibrous ankylosis or even a complete

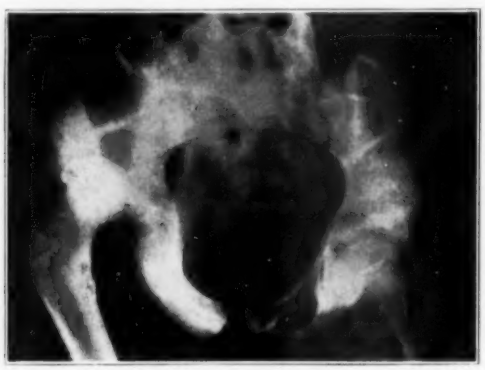

Fig. 4.—Roentgenogram showing spontaneous dislocation of the hip following metastatic infection. The dislocation was caused by distention of the capsule of the joint plus a vicious position of flexion and adduction (courtesy of Dr. D. H. Levinthal).

false joint. The function in these cases is likely to be poor, and chronic osteomyelitis may develop in the false joint as the patient reaches adult life. In older children the upper epiphysis of the femur is likely to separate, requiring its removal as a sequestrum before healing will occur. Bony ankylosis is then usually the end-result. The virulence of the organism is also an important factor. Infections produced by Staphylococcus aureus are the most virulent and destructive. Infections produced by the hemolytic streptococcus are a close second in this respect.

The type of therapy may also determine the end-results. Early diagnosis is essential to permit early drainage before much destruction has taken place. This point cannot be overemphasized. Almost the

entire course of the disease depends on early diagnosis and proper therapy. Otologists must be firmly impressed with this fact. This subject is not being presented to otologists to enable them to diagnose and treat metastatic suppurative disease of the hip. On the contrary, it is to emphasize the extreme difficulty one may experience in arriving at a correct diagnosis in the early stage when proper therapy must be instituted. It is needless to say that the otologist should avail himself of the best orthopedic consultation as soon as, and whenever, this is possible. When this cannot be done one should not hesitate to undertake early diagnostic aspiration when indicated and when pus is found to proceed with immediate surgical incision and drainage.

SUMMARY

Metastases, especially to the hip, are not uncommon, particularly in children, during the course of otogenic sepsis.

This sepsis may or may not be associated with thrombosis of the lateral sinus or jugular bulb.

Early diagnosis of metastases to the hip, though at times difficult, is essential to avoid serious complications and sequelae.

Early surgical incision and drainage with traction and either immediate mobilization or at least motion as soon as the acute symptoms have subsided seem to be the treatment of choice in suppurative conditions in and about the hip joint.

Expert orthopedic consultation should be utilized as early as possible.

Otologists should be constantly on the lookout for evidences of metastatic involvement of the joints in the presence of otogenic sepsis.

180 North Michigan Avenue.

Clinical Notes

STEREOSCOPIC ROENTGENOGRAMS OF THE SPHENOID SINUSES

JAMES W. FERGUSON, M.D., PITTSBURGH

The fundamental requirements for stereoscopic roentgenograms of the sphenoid sinuses do not differ from those for stereoscopic roentgenograms of other parts of the body, although the positions for the patient, the necessary apparatus and the anatomic structures differ considerably. In roentgenography of the sphenoid sinuses various positions for the head have been recommended; for instance, in the Granger position, shown in figure 1, the head is at an angle of 107 degrees. In another method the film is placed at an angle of about 24 degrees from the top of the table and a projection is made through the region of the vertex and the mouth, while in another method the head is placed on the side, parallel to the top of the table, and a lateral projection is made.

It is not my intention to offer diagnostic advantages gained from the use of any particular position, but rather to acquaint the reader with some important fundamental requirements for stereoscopic roentgen examination of the sinuses, to introduce a practical way of marking the films at the time of exposure and to describe the use of a device for making stereograms of these parts which I have used in research and in the check-up of various positions, the results of which will be published at a later date.

Granger has worked out, as a valuable aid in diagnosis, a definite position for the head and an angle of projection for the roentgen rays to depict certain parts of the sphenoid sinuses. A single roentgenogram containing his G (Granger) line, like all flat, single roentgenograms, does not present the sinuses as do stereoscopic roentgenograms. When one views a single roentgenogram the G line appears to be closely pressed or located against the frontal region; it seems flat; in fact, the whole image appears without form or depth and is more or less distorted.

If one views a pair of stereoscopic roentgenograms made of the same region objects take on a different aspect; instead of the parts appearing close together there are space and distance between the G line and the frontal regions. One is able to see distance between the ethmoid regions and the G line; the G line stands out with form, and if viewed to gain true stereoscopic effect the frontal region is seen to be nearest to the observer, with the occipital region receding, while the G line is seen with form in relief and solidity in relation to other objects within the skull, essentially as it would be seen were one to view a glass sphere or glass skull with the natural two eye stereoscopic vision.

It is evident that to produce a stereoscopic effect one must have two roentgenograms. Figure 1 shows a conventional device for making roentgenograms of the sphenoid sinuses with the patient's head in the Granger position. With this device it is impossible to remove the first exposed film so as to insert a second

without moving or disturbing the position of the head, which violates one of the most important essential requirements for roentgen stereoscopy.

With my apparatus (fig. 2) the film can be removed and another inserted for stereograms or duplicates without disturbing or moving the head of the patient, which allows fulfilment of the requirements to make a pair of stereograms. Many positions for the head and angles of projection for the roentgen rays have been recommended by various workers for making roentgenograms of the sinuses, all of which have been claimed by the originators to be of a definite value in diagnosis. To have an angle-board or head-rest for each one of these positions would require several devices of the conventional type, because each has a certain fixed angle. Hence, the practicability of having an adjustable angulating device, such as that shown in figures 2 and 3, is evident. This device can be quickly adjusted at various angles to suit different cases and requirements; it allows for any angle from the horizontal position to 25 degrees on either side of the horizontal position.

Fig. 1.—A conventional device for making roentgenograms of the sphenoid sinuses with the patient's head in the Granger position.

The sloping position of the head-rest used for some of the positions and the small circular diagnostic field usually desired in making roentgenograms of the sinuses continually cause difficulty in marking the roentgenograms properly. Sometimes the marker becomes displaced and does not appear on the film, and often the question arises as to whether or not the film is correctly marked. Marking is important at all times, but it is exceedingly important that stereographic roentgenograms be correctly marked because by transposition of the roentgenograms in the stereoscope all the objects in the image become reversed in an orderly manner, making what was thought to be the right side appear as the left side.

Figures 3 and 4 show some of the features of my device for marking the films at the time of exposure to the roentgen rays. The mat in figure 4 is cut to fit over the window or top of the head-rest. The marking letters L or R can be made to disappear or appear within the field of exposure by the lever Marker

Changer. With either marker placed within the circle the letter is correctly depicted in all postero-anterior projections of the sinuses; it cannot be otherwise. This is useful for marking roentgenograms not only of the sphenoid sinuses but also of the antrum, the ethmoid and frontal sinuses and the mastoid processes. The technic of marking the latter films will be described in another article.

In the instrument shown in figure 3 the marker is of aluminum with lead letter inserts, and when once placed in the aperture provided for the purpose it cannot be displaced. It will always appear within the area of exposure but out of the diagnostic field; on account of the reversed or pattern style of the letters the marker will be seen on the finished film in reverse, so that when a roentgenogram is viewed and the L or R appears in a correct readable position the viewer will be looking at the image on the film as he would view a patient facing him. The side of the object that was closest to the film when the exposure was made

Fig. 2.—A new device for making roentgenograms with the patient's head in the Granger position with which duplicates or stereograms can be made.

will be toward the viewer's eyes. The visual perception will be similar to that gained in viewing real objects; that is, the near objects will be brighter, with more distinctness and detail than the more distant parts, which always appear blurred and less distinct. It is a relief to one who prepares roentgenograms to know that the films are correctly marked at the time of the exposure, and it is a great satisfaction to one who views them, contemplating operative procedure, to know that the markers are on the correct side.

To make stereograms with the patient's head in the Granger position (fig. 2) the patient is placed in the recommended position. The cassette is inserted when desired; after the first exposure the lift, CL, is released, the film container is removed and another film is inserted for the second exposure.

After the rays are once centered over the central portion of the film, within the tunnel of the head-rest, no more centering is required. The tunnel is mounted

so as to move about a point (*O*, in fig. 3) which is on a level with the film, so that the tunnel and the film can be moved on either side of the horizontal plane without disturbing the position of the central rays, a frequently desired feature not found in any of the conventional devices.

Since it is the detail that is focused on the retina of each eye and since each eye sees the picture intended for that eye it is obvious that both images must have good detail. If one or both images are blurred or lack detail there will be a corresponding muddling at the receiving and realizing mechanism of the brain, with more or less confusion, resulting in failure to obtain a clearcut image. Therefore, neither the patient nor the film must be moved during exposure to the roentgen rays. The nearer to the film the object is placed the nearer in size the image will approach normal and the better detail the image will have. To accom-

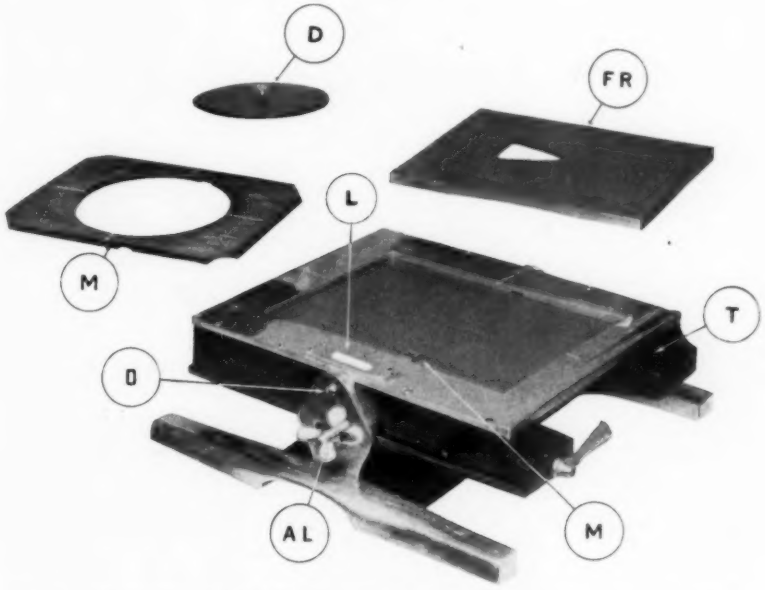

Fig. 3.—The parts of the head-rest which make possible the adjustment of the patient's head and the film at any angle.

plish this I have equipped the device with a lift (*CL*, fig. 2) which is used to raise and firmly hold the cassette and the film against the top of the head-rest.

Some workers have recommended darkening the portion of the film which surrounds the centrally located image. The darkened margin holds back, or prevents, an unnecessary access of light from entering the eye, allowing the image to appear more sharply outlined, with more contrast between the light and the dark shadows.

This darkening process is conveniently carried out by simply placing the lead disk (*D*, fig. 3) within the central window of the mat (*M*, fig. 3), which is placed on the head-rest; by short exposure to the roentgen rays the outer portion of the film around the disk is darkened while the central image under the lead remains unchanged.

A detail picture of the head-rest is shown in figure 3. The device consists of a tunnel or box, *T*, to receive a cassette, or film-holder. The small lever on the

left-hand side of the tunnel is used to lift the cassette and firmly hold it in place. The base is provided with hand-holds for convenience. The tunnel of the cassette moves at the point *O* and is locked by *A L* in the desired position. The marker, *M*, has been described in the preceding paragraphs. A spirit level is placed at *L* on the head-rest to facilitate positive leveling. A thin cut-out mat, *M*, transparent to the roentgen rays, is placed for certain types of roentgenograms over the window portion of the head-rest. A lead disk, *D*, fits into the cut-out mat, *M*, and is used in the darkening process described earlier. A face-rest (*F R*) is shown in use in figure 2.

One may conclude from a study of the description that a device is now available for making stereoscopic roentgenograms of the sphenoid sinuses with the patient in the Granger position at an angle of 107 degrees, that because of the adjustability of the device it can be used for making roentgenograms, in single, dupli-

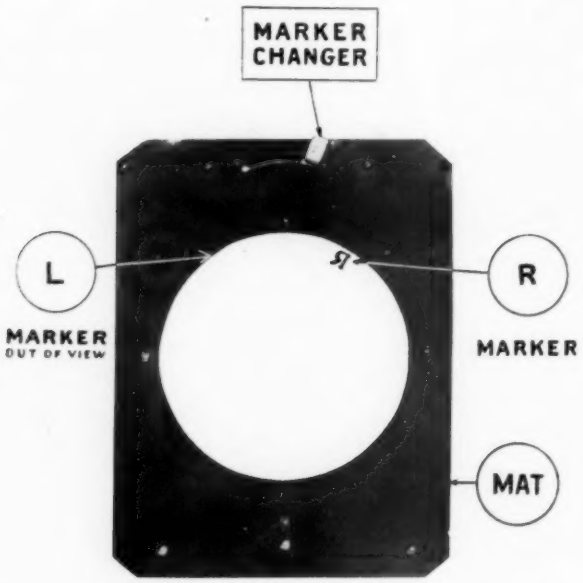

Fig. 4.—The mat which carries the adjustable marker and which is cut to fit over the window or top of the head-rest. *R* or *L* can be correctly depicted in all postero-anterior projections.

cate or stereoscopic form, of the other sinuses and that a practical method is available for marking or labeling the film at the time of the exposure so that either side of the patient's head can be determined without hesitancy or doubt at the time of viewing the roentgenograms.

I do not assume credit due any one else for working out a position from which to make roentgenograms of the sinuses, but I desire to offer a dependable method for marking the roentgenograms, and to introduce a device, an adjustable angulating head-rest, for making exposures in various positions, from various angles and in stereoscopic form. Owing to its special angulating features this device is recommended for use in making roentgenograms of the other sinuses, the face and the head.

NEW INSTRUMENTS FOR NASAL RECONSTRUCTIVE SURGERY

ARTHUR JOSEPH BARSKY, M.D., NEW YORK

These simplified instruments for nasal reconstruction are presented here only after exhaustive and thorough tests have proved their usefulness. It will be seen that each instrument is designed to assist in the accomplishment of a certain step in the operation. The instruments have been so simplified that there are no complicated parts which can get out of order; cutting instruments may be readily sharpened.

For infiltration of a local anesthetic the automatic continuous injection syringe has been invaluable (fig. 1). This is a modification of the Pitkin syringe. The

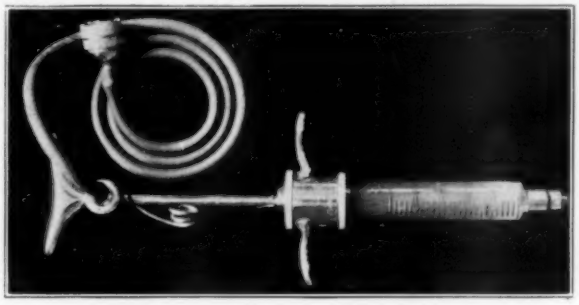

Fig. 1.—The automatic continuous injection syringe.

Fig. 2.—The top illustration shows the ribbed-back knife and the lower one a transfixion knife.

broad palm-rest and finger-rests make the syringe comfortable to handle and permit sufficient pressure to infiltrate the tissues with perfect ease. The bent stainless steel spring pulls the piston out and at the same time automatically refills the barrel. Since it takes up less room, a bent spring was used in preference to a coil spring, and the necessity of having a plunger too long and awkward to handle was avoided. Thus the surgeon has merely to press the plunger in; the return of the plunger and the refilling are automatic. Effort is reduced to a minimum. By the use of this syringe the nasal tissues are quickly and effectively anesthetized, and the least possible number of cutaneous punctures is required.

The ribbed-back knife (in fig. 2) is used to make the intercartilaginous incision. The rib is on the upper convex surface. As the point of the knife enters the tissues and is advanced the rib raises the skin of the dorsum, thus preventing

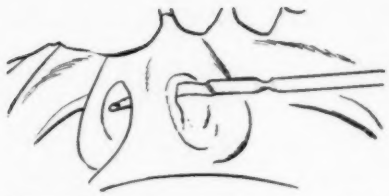

Fig. 3.—Diagram showing transfixion of the columella.

Fig. 4.—The double-edged scissors with the rounded tip.

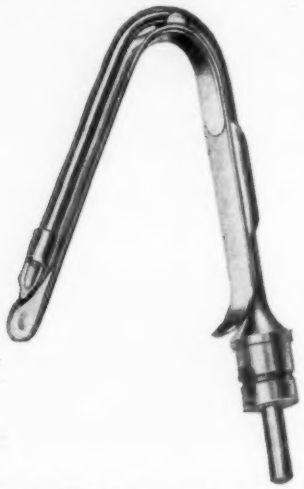

Fig. 5.—The illuminated retractor.

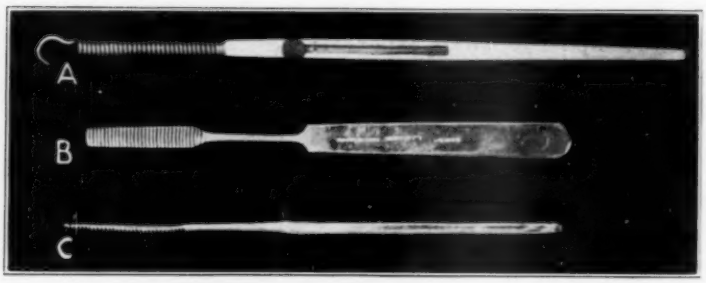

Fig. 6.—*A* is the rigid and flexible hook; *B*, the rasp, showing the concavity of the cutting edges; *C*, the rasp, showing the direction of the teeth.

any possibility of perforation. The rib may be removed when the knife must be sharpened.

The transfixion knife (in fig. 2) has a concave cutting edge. The flat surface of the blade itself is curved lengthwise, concave on its under surface, convex on the upper surface. The end is protected by a button. The knife may be inserted in the incision on one side and the end pushed through to the incision on the opposite side, with the concavity of the blade following the curvature of the dorsum of the nose. The incision may then be continued along the columella (fig. 3). The button end prevents the possibility of damage to the alae.

The double-edged scissors with the rounded tip (fig. 4) are used for undermining the dorsum of the nose. The curved scissors are sharpened on the outer

Fig. 7.—The ice-tong tenaculum.

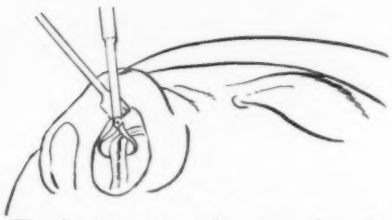

Fig. 8.—The ice-tong tenaculum grasping the septum.

Fig. 9.—The pressure-clamp for the angular artery.

as well as on the inner edge and cut both on the opening and on the closing of the blades. The tip, though rounded, is sharp. Cleancut undermining is thus assured, and no shreds of tissue or unsevered areas are left. The curve of the scissors is such as to make buttonholing almost impossible.

The illuminated retractor (fig. 5) consists of two parts: a retractor and a light-carrier. The retractor may be boiled and the light-carrier may be sterilized in solutions. The latter is clamped firmly on the former. The instrument enables the surgeon to carry out a careful visual examination of the dorsum beneath the skin. Each part may also be used alone, the retractor as a simple retractor and the light-carrier to transilluminate the alar cartilages.

The rigid and flexible hook (fig. 6*A*) has a variety of uses. It may be used in its rigid state. When it is desirable to have the hand holding the instrument

out of the field the instrument may be bent at any angle by pushing the button up into the handle.

The rasp is used to smooth the dorsum after the removal of the hump. It is designed to cut cartilage as well as bone. The cutting edges are concave transversely (fig. 6 *B*), and the teeth point toward the handle (fig. 6 *C*). The instrument cuts only on the pull stroke and will not slide laterally off the septal cartilage, nor can the cartilage buckle beneath it.

The ice-tong tenaculum (fig. 7) is used to hold the lowermost portion of the septum rigid. This permits symmetrical excision of a small part of the septum

Fig. 10.—Demonstration of the use of the pressure-clamp.

Fig. 11.—The double-edged scissors with the pointed tip.

in order to shorten the nose (fig. 8). Gentle traction maintains a firm grip, and the instrument is easily released by a downward motion.

When troublesome bleeding of the angular artery is encountered the pressure-clamp (fig. 9) may be used to stop the bleeding until pressure bandages can be applied. The soft rubber ends and the proper spring-tension prevent damage to the tissue (fig. 10).

For undermining the lower lateral alar cartilage the curved, pointed scissors are ideal. These scissors are sharpened along the entire inner edge and along the outer edge for a distance of about ½ inch (1.2 cm.) from the point. They cut both on opening and on closing. With these scissors the cartilage can be undermined with surprising ease (fig. 11).

MULTIPLE BARBS OF THE HEDGEHOG-CATERPILLAR AS PHARYNGEAL FOREIGN BODY

Report of a Case

F. H. McGovern, M.D., University, Va.

The hedgehog-caterpillar, Isia isabella S. is commonly classified among the insect pests of garden and field crops, with no direct or indirect pathogenicity for man. It is thickly covered with close-cropped, soft hairs, brownish red along the middle of the body and black at either end. Under the microscope the hair is seen to consist of a main stem with one or two projecting barbs, resembling rose thorns (figure).

A case was recently seen in which the patient inadvertently ate a hedgehog-caterpillar with a spoonful of cabbage. The cabbage was eaten cold, having been cooked the evening before. The patient immediately experienced sharp discomfort in the pharynx and spat out the mouthful of food. In her excitement at finding

Photomicrograph of a barb from the hair of the hedgehog-caterpillar.

a caterpillar she failed to notice whether it was dead or alive. For three days the pain on swallowing was so severe as to prohibit eating or drinking almost entirely. The weakness following the inadequate intake of food forced the patient to seek medical aid.

Examination showed the tongue, mucous membrane of the cheeks, hard and soft palates, tonsillar pillars, tonsils and posterior pharyngeal wall as far down as the epiglottis to be covered with hundreds of tiny hairs. Because of the resistance of the projecting barbs difficulty was encountered in extracting the hairs embedded in the mucous membrane; however, more than one hundred barbs were extracted with tweezers. The patient was given a 2 per cent solution of butyn to use as a pharyngeal spray. The next day more hairs were removed, and the patient gradually recovered from her unusual experience. Except for redness and swelling of the lips no other toxic effect of the presence of the foreign body was noted.

From the Department of Otolaryngology, University of Virginia Hospital.

INSTRUMENT FOR THE REMOVAL OF A BEAD FROM THE BRONCHUS

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The removal of foreign bodies from the bronchial tree is a never-ending study. New types of foreign bodies are continually presenting themselves, the removal of which is difficult despite previous experience in the removal of similar objects and despite a vast array of instruments. The Jacksons [1] have described a variety of glass beads and have suggested the use of the ball or fenestrated forceps for round beads and the four-jawed forceps for oval, square, conoid or pyriform beads.

In one case which I recently observed the bead was almost cylindric, too long to be grasped safely by any of the aforementioned instruments and too well impacted in the bronchus to permit the passage of a hook beyond its distal end. When first aspirated by the 3 year old child, the bead was loose in the trachea. Attempts to

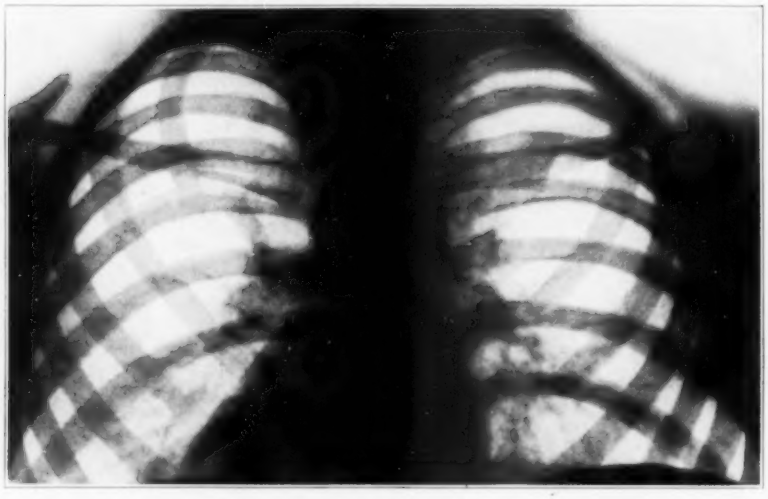

Fig. 1.—Roentgenogram showing location of cylindric bead in the main bronchus on the right side.

grasp it were unsuccessful because it moved rapidly up and down, its slippery surface easily eluding the various forceps introduced. The small four pronged forceps might have been successful had the distal spread of the prongs been sufficiently wide. Within a few minutes the bead was sucked into the right main bronchus where it remained, its long axis in line with that of the bronchus and the hole in the bead presenting almost exactly in the center of the bronchial lumen.

I decided against using a hook or Boot's spiral because of the length of the bead, its impaction and the danger of entering a branch bronchus through blind manipulation. Instead, I had a mechanic make a spiral thread at the distal end of a long, straight, thin rod of monel metal so as to resemble a finely tapered

1. Jackson, Chevalier, and Jackson, Chevalier L.: Bronchoscopy, Esophagoscopy and Gastroscopy, ed 3, Philadelphia, W. B. Saunders Company, 1934, p. 221

wood screw. This was easily threaded into the hole of the bead; two or three turns made it fast, and the bead was then drawn up to the end of the tube, with which it was readily extracted. There was slight resistance at the glottis but the screw held fast.

It is not likely that this instrument would be applicable to the removal of a round bead unless it were firmly wedged in swollen mucosa, because, even assuming that the hole was presenting, any attempt to engage and thread it would probably

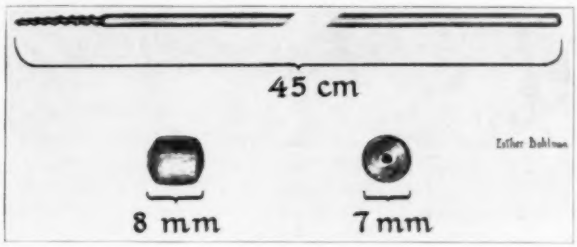

Fig. 2.—New instrument designed to remove a bead from the bronchus.

force the bead farther down. In the case to which I have referred the cylindric shape and the length of the bead made it impossible for the presentation to change. As it could not descend farther, I believed it safe to use the instrument described. It was surprising to note how easily the sharp threads of the screw cut into the glass under the light pressure of the manipulating fingers.

25 East Washington Street.

Abstracts from Current Literature

Ear

THE EXCITATION PROCESS IN THE CUPOLA. K. WITTMAACK, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **139**:1, 1935.

Wittmaack discusses the differences in opinion between himself and Steinhausen and evaluates the two theories that have been advanced about the nature of the process of excitation in the cupola: his own theory and the Mach-Breuer theory. The latter is defended by Steinhausen. He points out that the question is not: "Is it possible to effect a deviation of the cupola and during this deviation observe a process of excitation?" but rather "Is the natural process of excitation in the cupola produced by pressure or by the possibly consequent deviation of the cupola?" He shows that Steinhausen's method of experimentation is not suited to the clarification of this problem. The chief error of Steinhausen's method is his failure to take cognizance of the differences that exist between a closed and an open or a half-open fluid system, and of how this is bound to lead to erroneous results and to erroneous conclusions. He emphasizes that for the theory explaining the nature of the excitation in the cupola only indirect proofs are possible. He thinks that a number of factors indicate that the process of excitation is the result of pressure and not of a deviation of the cupola. He mentions the most important of these factors and then emphasizes once more that experiments on the opened and artificially altered labyrinth cannot give correct information about the physical and physiologic processes that take place in the naturally functioning closed labyrinth.

EDITOR'S ABSTRACT.

COMPARATIVE STUDIES ON THE HISTOLOGY OF OTOSCLEROSIS. A. GREIFENSTEIN, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **139**:14, 1935.

Greifenstein presents an extensive histologic study of otosclerosis. Most of his investigations are comparative pathologic-anatomic studies. They concern problems that are encountered in the study of various pathologic bone processes, and he intends to compare the changes that appear in other transforming bone diseases with the histologic and histogenic changes of otosclerosis. He demonstrates identities and divergences and attempts a causal interpretation. After discussing the improvements in polarization microscopy, he gives a detailed description of extensive otosclerotic changes in a labyrinthine capsule. Then he compares with otosclerosis various types of regenerative bone processes, such as fracture callus and the bone regeneration in cases of trepanation defect. Further he concerns himself with the regeneration of the spongioid and compact otosclerotic bone. As the most important and surprising result of his comparative studies on bone regeneration and otosclerosis, he finds extensive histogenetic similarities. He stresses that the young otosclerotic process, particularly its medullary portion, has considerable osteogenic capacities. The following section of the study is devoted to otosclerosis and osteogenic formations, to exostoses and osteophytes, to the so-called osteomas of the accessory cavities and to the so-called strand bone. The subsequent chapter concerns otosclerosis and the functionally conditioned bone transformation. Under this heading are discussed vicarious osteosis and zones of true resorption and transformation. In the last chapter he reports comparative studies on the intravital cleft formations of the labyrinthine capsule. At the end of each chapter he summarizes the similarity between the bone changes and the otosclerotic changes. Taken as a whole, the comparative studies permit the conclusion that the young otosclerotic focus is a regenerative new formation that develops following a previous osteoclastic resorption of the labyrinthine capsule;

that is, it is a resorptive new formation. To this comparative histologic proof can be added a biologic proof, namely, the observation that the medullary tissue of the young otosclerotic focus shows, after a trauma, a lively regenerative activity in the form of callus formation. It is pointed out that research on the cause of otosclerosis must consider the following factors: 1. The abnormally wide and congested blood vessels, which Wittmaack made the focal point of a theory of stasis, are found in the various processes of transformation, particularly in osteomas, but also in the doubtlessly functionally conditioned experimental transformation zones. 2. Close histogenetic relations exist between otosclerotic and functionally originating processes of transformation. 3. Comparative studies on the regenerative capacity and the healing processes in operatively produced fissures of the labyrinthine capsule do not justify considering the so-called spontaneous fissures as artefacts. Intravitally originated fissures in animals resemble greatly the spontaneous fissures in the labyrinthine capsule, and their development closely resembles the circumscribed resorption and transformation processes. The theory of a mechanical-functional genesis of the otosclerotic foci advanced by O. Mayer is given further support by the comparative studies on the histology of otosclerosis.

EDITOR'S ABSTRACT.

THE RÔLE OF THE MEMBRANA BASILARIS IN THE PERCEPTION OF OCTAVE HARMONY. O. GOEBEL, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **139**:100, 1935.

Goebel emphasizes that formerly not sufficient attention was given to the fact that when a faint tone changes into a loud one the nature of the tone is changed. He points out that according to Stumpf the octave ratio dominates in the music of all peoples. He thinks that the perception of harmony (the equality of partial perceptions of two tones that have octave relations) is the result of identical intramolecular processes in certain hearing fibers. This practically forces the conclusion that the two external hearing cells or their nerve fibers, respectively, which probably provide the higher perception component of a tone, must have an intramolecular oscillation which persists only half as long as that in the internal hearing cells and their nerve fibers. That is, the pressure of the tectorial membrane on the hairs of the external hair cells can last only half as long as that on the hairs of the internal hair cells. The first problem to which Goebel gives his attention is at what moment of the plus first phase of an oscillation the pressure of the tectorial membrane on the hairs commences and with this the stimulation of the pertaining nerve fibers, the onset of the impulse current in them. He differentiates four different phases: the plus first and second phases and the minus first and second phases. He agrees with Böttcher, Shambaugh and Wittmaack that the tectorial membrane is connected with the internal and external supporting cells and the hairs of the hair cells. He then explains what happens during the plus first phase and during the other phases in the membrana basilaris and the adjoining structures. He shows that there is a possibility that the stimulation of the external hearing cells takes up only one half of the plus second phase whereas the internal hearing cells respond during the entire plus second phase. He demonstrates also that the frictional electricity has no connection with the hearing process. He says that the hearing cells are not stimulated by molecular pressure waves that pass through them during the plus first and second phases of tones. For this process of stimulation pressure of the hairs and depression of the hair cell surface are necessary. Relatively strong tensions must be produced in the molecules of the hearing cells if they are to be stimulated. Goebel points out that the organ for sound perception in the cochlea of reptiles and birds differs considerably from that of human subjects, but the qualitative hearing capacities of these animals are not inferior, as is indicated by the imitation of noises and sounds by certain birds. The organ of Corti appears first at the stage of terrestrial mammals, that is, in that group of animals in which a pinna, a sound collector, also makes its appearance. Goebel thinks that the quantitative hearing may have

improved thereby; the ear may have become more sensitive for faint sounds. The lengthening of the cochlea, the presence of only a few hair cells in a cochlear cross-section seems to indicate that the sound differentiation likewise has improved. As a result of the considerable limitation of the number of hearing cells per cross-section the free portion of the membrana basilaris had to become much wider. This had the disadvantage that the inner thin portion of the membrana basilaris had to be dilated too rapidly and too strongly, and the fine differentiation of sound perception would have been impaired by this. However, this was forestalled by two devices: by Reissner's membrane and by the peculiar pillar construction that prevents the too rapid and too strong tension of the inner portion of the membrana basilaris during the plus first phases and the too rapid upward movement of this portion of the membrana basilaris during the plus second phases.

EDITOR'S ABSTRACT.

RELATIONS BETWEEN THE VESTIBULAR APPARATUS AND THE VEGETATIVE NERVOUS SYSTEM. R. LEIDLER, Monatschr. f. Ohrenh. **69**:1 (Jan.) 1935.

Before discussing the influence of the vestibular apparatus on the vegetative system, Leidler reviews what is known regarding the portions of the vegetative system within the central nervous system. He mentions the centers that are found in the spinal cord, in the medulla oblongata, in the mesencephalon and in the diencephalon. Then he gives his attention to the anatomic connections between the vestibular nerve and the aforementioned autonomic spheres within the central nervous system, enumerating those that are known as well as those the existence of which may be assumed on the basis of physiologic and clinical experiences. In discussing the connections between the vestibular nerve and the autonomic areas within the spinal cord he mentions the fasciculus deitersospinalis and the fasciculus longitudinalis posterior and points out that connections have been demonstrated between the nuclei of the vestibular nerve and the motor cells of the anterior horn. Since it is known that these cells are of the same origin as the autonomic cell group of the spinal cord, the nucleus intermediolateralis and the nucleus intermediomedialis, it may be assumed that there are also connections between these cells and the descending tracts that originate in the region of the nucleus vestibularis. Leidler further discusses the connections of the vestibular nerve with the autonomic regions in the medulla oblongata, the mesencephalon and the diencephalon, describing first the nuclear region of the nucleus vestibularis triangularis and then the fiber region of the same nucleus. In the discussion of the function of the anatomic formations he hopes to give a better insight into the relations of the vestibular apparatus to the vegetative system. He points out that the spinal cord contains vegetative centers which, under normal conditions, function almost never independently but always under the influence of higher centers. However, experiments and disease conditions have demonstrated that these vegetative centers are capable of independent reflexes. The autonomic fibers that originate in the medulla oblongata belong to the parasympathetic nervous system. He mentions the centers for the secretion of saliva, for the secretion of tears, for vasomotility, for metabolism, for water and sodium chloride exchange, for the gastro-intestinal tract and for respiration. In this connection he gives attention also to the mechanism of vomiting and to the intake of food. The mesencephalon contains the pupillary center. Concerning the diencephalon he says that for some of the internal organs a diencephalic regulatory center has not been demonstrated as yet. Other internal organs, such as the gastro-intestinal tract and the uterus, seem to have a diencephalic center, but exact localization is not definitely known. He further discusses the influence exerted by the functions of the vestibular apparatus on the vegetative nervous system. He considers the vestibular pupillary reflex and the actions of the vestibular apparatus on the vascular system, the heart, the respiratory mechanism and the digestive tract and on metabolism. EDITOR'S ABSTRACT.

PATHS OF COMMUNICATION BETWEEN THE SUBARACHNOID SPACE AND THE LABYRINTH. L. N. JAMPOLSKY, Monatschr. f. Ohrenh. **69**:23 (Jan.) 1935.

Jampolsky shows that the subarachnoidal space is connected with the labyrinth by two preformed passages: the cochlear aqueduct and the perineural path. Of the serous labyrinthine cavities only the perilymphatic one is connected with the subarachnoidal space; the endolymphatic space is not. The circulation of the perilymphatic fluid is extremely weak. The perilymph may develop as the result of the penetration of the fluid into the labyrinth from the outside but may also be formed inside of the labyrinth. He regards the perilymphatic space of the labyrinth as a system of accessory sinuses of the subarachnoidal space which, like the subarachnoidal space, perform drainage functions. Intravital introduction of dialyzed india ink into the subarachnoidal space is followed by its appearance in the labyrinth, where it produces a mild inflammation. Repeated introduction of india ink into the subarachnoidal space produces a localized form of fibrinous suppurating labyrinthitis and thus proves the possibility of the existence of localized forms of labyrinthitis.

EDITOR'S ABSTRACT.

SURGICAL INTERVENTION IN A CASE OF PRIMARY CHOLESTEATOMA OF THE APEX OF THE PETROSA. K. BECK, Ztschr. f. Hals-, Nasen- u. Ohrenh. **37**:117, 1934.

According to Beck, primary as well as secondary cholesteatoma of the temporal bone develops as the result of heterogenous tissues. The one is congenital, the other postfetal, but the anatomic aspects of both are the same. He thinks that secondary cholesteatoma may be excluded when there are no signs of an existing or a former otitis media and when the tumor is at a site which has no topographic connection with the spaces of the middle ear. Primary cholesteatoma of the middle ear is rare. It develops chiefly at the point where the temporal, parietal and occipital bones converge, or it may occur in the pneumatic spaces, and then secondary otitis media may develop. He points out that a primary cholesteatoma at the petrosal apex was described by Lehmann in 1912. Moreover, primary cholesteatoma that originates in the pia is occasionally localized here and produces the symptoms of a tumor of the cerebropontile angle. In view of the rarity of such cases, Beck describes one observed by himself in a woman, aged 20, who complained that during the last six months her hearing had become poor on the right side and that recently facial paralysis on the right side had developed. Following otologic and neurologic examination, roentgenography was resorted to. The right ethmoid bone was somewhat more penetrable for the rays than the left one, and the pyramidal apex could not be recognized. Careful observation disclosed the slightly upwardly curved line of the right upper pyramidal contour and below that a structureless area of lesser density about 2 cm. in length and 1 cm. in diameter. Beck describes the surgical procedure by which the cholesteatoma was removed. In spite of extreme caution the dura was torn, and the gush of the cerebrospinal fluid flooded out additional masses of cholesteatoma. The patient recovered. Beck points out that the intact middle ear, the normal pneumatization, the entire separation of the cholesteatoma from the middle ear spaces and the anamnesis indicate that this was a primary cholesteatoma. He concedes that, although in this case the operation was successful, the prognosis is usually doubtful.

EDITOR'S ABSTRACT.

RÔLE OF THE FRONTAL LOBE IN THE DEVELOPMENT OF NYSTAGMUS. J. OHM, Ztschr. f. Hals-, Nasen- u. Ohrenh. **37**:122, 1934.

In introductory remarks Ohm gives an outline of the innervation of the muscles of the eye at which he arrived on the basis of observations on more than 3,000 cases of nystagmus. He differentiates the vestibular, the optical and the volitional routes of innervation and thinks that there exists an accessory connection between the optical and volitional routes, the course of which is still unknown. He further

discusses various routes and centers and then evaluates observations made by Bartels in cases of war injuries of the frontal convolutions. He thinks that one should not speak of cortical nystagmus or of cortical fixation nystagmus but rather of frontally conditioned vestibular nystagmus. Then he discusses the influence exerted by the frontal visual center on the various types of nystagmus: on vestibular nystagmus, on optokinetic nystagmus, on the nystagmus of the terminal position, on congenital nystagmus, on miner's nystagmus and on volitional nystagmus. He gives especial attention to optokinetic nystagmus in cases of motor aphasia. He shows that it is advisable to study the optokinetic nystagmus in all speech disturbances.

EDITOR'S ABSTRACT.

ANATOMIC STUDY OF THE PNEUMATIZATION OF THE PETROUS BONES AND CELL PATHWAYS LEADING TO THE APEX. A. TOBECK, Ztschr. f. Hals-, Nasen- u. Ohrenh. **37**:152, 1934.

Tobeck shows that a knowledge of the pathways by which pneumatization of the pyramid takes place and an acquaintance with the possibilities for an extension of the pneumatization in the petrosa are of fundamental significance for the diagnosis, prognosis and treatment of suppurations of the apical cells (petrositis, apicitis). In cases in which a suppuration of the pyramidal cells is suspected he considers it essential to determine which pathway of cells is diseased. He shows that there are four pathways of cells: One, which he designates as the posterior path, originates in the antrum; the second, the superior one, comes from the recessus epitympanicus; the third, the inferior one, originates in the hypotympanic recess, and the fourth, the anterior one, pneumatizes first the lower wall of the osseous tube and finally may reach into the petrosal parts behind the carotid canal. He emphasizes that in view of these different routes of infection a standard operation is impossible. He shows that in one case it is essential to expose the pyramidal apex in the region of the middle cranial fossa, and in another, in the region of the posterior cranial fossa, while in still another case an attempt must be made to reach the basal portions of the pyramid.

EDITOR'S ABSTRACT.

Pharynx

EFFECTS OF TONSILLECTOMY ON ANTITOXIC IMMUNITY TO DIPHTHERIA IN A RURAL POPULATION. W. A. BUICE, Lancet **1**:790 (April 14) 1934.

A Schick test was performed on 232 rural children. Of the tonsillectomized subjects, 68 (62 per cent) gave positive Schick reactions. Of those with the tonsils intact, 84 (69 per cent) gave positive reactions. The proportion of positive Schick reactions among both the tonsillectomized and nontonsillectomized children remained practically on a level through all the age groups. The children, without regard to the factor of tonsillectomy, did not appear to be acquiring immunity to diphtheria as they grew older, which is in contrast with the findings of Zingher and other investigators working among children in large cities.

LANGMANN, New York. [AM. J. DIS. CHILD.]

THROMBOSIS OF THE JUGULAR VEINS AS A COMPLICATION OF TONSILLAR INFECTION TRANSMITTED BY WAY OF THE LYMPH VESSELS. W. UFFENORDE, Ztschr. f. Laryng., Rhin., Otol. (Teil 1: Folia oto-laryng.) **25**:307, 1934.

Uffenorde describes and discusses several cases. The first illustrates the process of transmission of the infection from the tonsils by way of the lymph vessels to the regional glands in a severe form as the possible beginning of a thrombosis of the jugular and facial veins and sepsis. In this case the tonsillitis with glandular swelling, which had been neglected by the patient, had produced a considerable number of adhesions between the inflamed glands and the vascular sheath and the

jugular and facial veins, but thrombophlebitis and sepsis had not developed. Above the adhesions an encapsulated abscess had developed in the parapharyngeal space. This abscess was separated from the peritonsillar inflammation. This is possible because the lymph vessels pass from the tonsil through the peritonsillar tissue and the lateral pharyngeal wall into the parapharyngeal space and farther to the main regional gland at the site of convergence of the venae jugularis and facialis communis. In such cases, with an encapsulated abscess of the parapharyngeal space, there is great danger of erosion of the vessels, but in this instance perivascular indurations had protected the vessels and thus had prevented sepsis. Uffenorde thinks that his method of opening the parapharyngeal space is advisable. He emphasizes that the space should be entered, not from above, but from below, the digastric muscle and along the internal jugular vein. Along the jugular vein the infection spreads from the parapharyngeal space to the mediastinum, and along this same route the lymph nodes are located. This path is the more suitable since the thrombosis of the jugular vein, a rather frequent complication, can be watched from here.

The second case illustrates the further course of the transmission of the infection by the lymph channels with secondary invasion of the blood stream and subsequent sepsis. Uffenorde describes three other cases and in the conclusion emphasizes that posttonsillitic sepsis develops by way of the lymph channels either directly or more often indirectly by spreading of the regional lymphadenitis with subsequent thrombosis of the jugular and facial veins. The treatment consists in complete enucleation of the palatine tonsils, opening of the vascular sheath with removal of the inflamed gland, careful inspection of the veins and opening of the parapharyngeal space. If the veins are thrombosed they are completely excluded.

EDITOR'S ABSTRACT.

Larynx

ESOPHAGEAL VARIX. EMANUEL FRIEDMAN, J. Pediat. **4**:641 (May) 1934.

A case of esophageal varix in a 3½ year old boy is reported. Repeated gastrointestinal hemorrhages occurred during a period of more than one year. Autopsy showed no other abnormal condition except the dilated veins in the lower part of the esophagus. Only ten cases have thus far been reported in which the condition was not dependent on hepatic cirrhosis. The literature on this subject is briefly reviewed. LEMASTER, Evanston, Ill. [AM. J. DIS. CHILD.]

FUNDAMENTALS OF THE THERAPY OF LARYNGEAL TUBERCULOSIS. C. AROLD, Ztschr. f. Laryng., Rhin., Otol. (Teil 1: Folia oto-laryng.) **25**:320, 1934.

Arold stresses two facts: 1. Laryngeal tuberculosis cannot be considered a purely local disorder but must be evaluated in connection with the tuberculous process that involves the entire organism. 2. Laryngeal tuberculosis nevertheless retains some independence in that under certain conditions various therapeutic measures may prove helpful. The other accompanying organic disorders do not necessarily keep step with it either as regards the rapidity or the mode of its development. Arold stresses the importance of the general treatment and shows that the local treatment must be adapted to the efficacy of the former. He thinks that the otorhinolaryngologist should not be satisfied with assuring himself that the pulmonary status favors a certain treatment or contraindicates it but should give attention to the patient's general condition and determine the therapeutic measures on this basis. He says that he has obtained cure of laryngeal tuberculosis in patients with severe pulmonary processes, and that he has seen laryngeal tuberculosis terminate fatally in patients without a pulmonary process. He emphasizes that the white cell picture is a reliable indicator of therapeutic measures.

EDITOR'S ABSTRACT.

Nose

CORYZA OF THE DOMESTIC FOWL. J. B. NELSON, J. Exper. Med. **61**:351 and 361, 1935.

The mucous surfaces of the nasal passages and orbital sinuses appear to afford particularly favorable conditions for the development of the bacillus of fowl coryza. Injected into the nasal tract in any appreciable number, the bacilli regularly develop and may continue to exist for a considerable period in spite of an active inflammatory reaction on the part of the host. The bacillus multiplies either sparsely or not at all when injected extranasally, regardless of the nature of the cellular surface with which it is brought in contact. If the locus of injection is in communication with the upper air passages, as in the instance of the trachea, internal ear and orbital cavity, the bacilli may be carried there even in the absence of a local development and produce coryza. Introduction of the bacilli in loci not in communication with the upper air passages is followed by nasal carriage only in the case of the peritoneal cavity. Following intraperitoneal injection of the bacilli, seven of twelve birds showed these organisms in the nasal passages and, except in one instance, without accompanying inflammation.

Intratracheal, intracloacal and subcutaneous injection of living cultures of the bacillus of fowl coryza had no demonstrable effect on the susceptibility of fowl to coryza. Intraperitoneal injection was irregularly followed by definitely altered susceptibility. Growth of the specific bacillus was inhibited in the nasal tracts of approximately 70 per cent of twenty-five birds which had received an earlier intraperitoneal injection. FROM THE AUTHOR'S SUMMARIES. [ARCH. PATH.]

PASSABLENESS OF THE NASOLACRIMAL DUCTS IN CASES OF NASAL DISORDERS. I. ABRAMOWICZ and T. WĄSOWSKI, Monatschr. f. Ohrenh. **69**:60 (Jan.) 1935.

The studies of Abramowicz and Wąsowski were carried out in order to determine (1) what pressure is required for the syringing of the lacrimal duct in cases of complete passableness of the nasolacrimal duct, (2) whether nasal changes are absent in these cases, (3) whether nasal changes exist and what they are in cases in which considerable pressure is necessary and (4) to what extent treatment of the nose influences the passableness of the nasolacrimal duct. The authors employed an instrument devised by Elschnig, which has the advantage that it records the amount of pressure on a scale. They concede, however, that this instrument is not entirely correct, and so they are attempting to modify Anel's syringe. The studies reported here were made with Elschnig's instrument. The material consists of 146 persons with various ocular and nasal disturbances. It was found that in cases of complete passableness of the nasolacrimal duct the pressure indicated on the scale varies between 0.5 and 2. In cases of impaired passableness the scale readings are higher. This was found in 86 per cent of the cases of nasal disturbance. The nasal disorders were: swelling of the mucosa in the lower part of the nasal passage, hypertrophy of the lower nasal concha, deviations of the septum, strongly developed cristae and spinae of the septum, acute inflammation of the nasal mucosa, chronic hypertrophic catarrh and chronic atrophic catarrh. It was found that any treatment of the nose which counteracts the obstructions in the lower portions of the nasolacrimal duct reduces the abnormally high pressure required for syringing. The authors conclude that recording the pressure required for syringing the lacrimal duct is helpful in the early diagnosis of a disturbance of this passage.

EDITOR'S ABSTRACT.

PATHOGENESIS OF ALA NASI SYMPTOM IN STUTTERERS. EMMA MOŚCISKER, Monatschr. f. Ohrenh. **69**:106 (Jan.) 1935.

Mościsker shows that in associative aphasia there are movements of the alae nasi that correspond to the alae nasi respiration during pneumonia. She thinks that they are the result of a hyperkinesia which in turn is caused by a disturbance

in the basal ganglions, and she considers it likely that the respiratory center as an intermediate link plays a part in the genesis of this symptom. She assumes that during pneumonia and during associative aphasia analogous chemical processes are at work.

EDITOR'S ABSTRACT.

ABSCESS OF THE FRONTAL LOBE AS A COMPLICATION OF ABSCESS OF THE NASAL SEPTUM. J. BERENDES, Ztschr. f. Hals-, Nasen- u. Ohrenh. **37**:148, 1934.

Berendes shows that, although abscesses of the frontal lobe have been described repeatedly as rhinogenic complications they nearly always had resulted from suppurations of the accessory nasal sinuses. He observed a case in which an abscess of the frontal lobe developed as a complication of an abscess of the nasal septum. He suspected an abscess of the frontal lobe, but the consulting neurologist diagnosed the condition as serous meningitis with cerebral edema. The patient died, and the necropsy revealed an abscess of the left frontal lobe. Since consent to an extensive necropsy could not be obtained, the mode of development of the cerebral abscess could not be definitely clarified. Berendes thinks that the lymph channels transmitted the process to the brain.

EDITOR'S ABSTRACT.

THE PROTEIN NITROGEN CONTENT OF THE SECRETION IN ACUTE AND CHRONIC SINUSITIS. F. W. DEILMANN and E. KUTSCHER, Ztschr. f. Hals-, Nasen- u. Ohrenh. **37**:165, 1934.

Deilmann and Kutscher found in studies on the behavior of the protein nitrogen in the secretions in acute and chronic disorders of the accessory sinuses that a single determination of the protein does not permit a conclusion as to whether the process is acute or chronic. Serial examinations reveal, in cases of acute sinusitis, great, irregular fluctuations of the protein content between 1 and 9 per cent. In cases of chronic sinusitis the protein content is more stationary with variations from 3 to 5 per cent.

EDITOR'S ABSTRACT.

Miscellaneous

DANGERS OF LOCAL ANESTHESIA AND THEIR PREVENTION. B. GRIESSMANN, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **139**:109, 1935.

Griessmann shows that the cannula hitherto used for injections, which has its opening at the end of the beveled point, is an imperfect instrument since, in being forced into the tissue, it cuts from the tissue a flap corresponding to the shape of its opening. If suction is applied, these flaps may obstruct the opening and thereby give rise to grave errors. Moreover, if portions of tissue are torn away, there is a possibility that, together with the injection fluid, they are pressed into lymph spaces, and if they enter blood vessels, they may give rise to an embolism. If the tissue portions that have been torn loose are infected, local or distant complications may arise in the form of abscesses and embolic infarcts. He describes an improved cannula that is closed at the beveled end. The opening for suction and injection is on the longer side and in a depression of the cannular wall. Because of the closed beveled point, the tissue is simply pushed aside and the cutting of flaps is obviated. The fact that the lateral opening is within a depression prevents its obstruction during suction. Griessmann describes the technic of injection in which the puncture canal is first tested for its freedom from vessels by a permanent vacuum and then, in the course of retraction, the puncture canal is saturated with the injection fluid.

EDITOR'S ABSTRACT.

MENINGIOMA OF THE POSTERIOR CRANIAL FOSSA. J. FISCHER, Monatschr. f. Ohrenh. **69**:40 (Jan.) 1935.

Fischer describes a meningioma of the posterior cranial fossa. He points out that the observations of Riehl indicate that dural endotheliomas may develop from

the endothelium of the dura, from the stroma of the dura or from the arachnoidal cones in the dura (described by M. B. Schmidt). If Cushing's statement according to which the last-named formations are the most important factor in the development of meningiomas is accepted the investigations of Aoyaga and Kyuno indicate that these accumulations of cells are found in the region of the posterior cranial fossa at the following sites: around the porus acusticus internus, in the region of the jugular foramen and in the surroundings of the transverse and sigmoid sinuses. On the basis of these statements and of the necropsy observations in this case it is highly probable that the tumor developed in the sinus region and then grew medially beyond the cerebral aperture of the aqueduct of the vestibule and along the posterior pyramidal surface, so that the region of the internal auditory meatus as well as the pars nervosa of the jugular foramen were not as yet attacked by the tumor. Fischer is aware that in view of the size of the tumor it is difficult to prove this assumption but thinks that on the basis of his necropsy observations it has a certain justification. Structurally considered, the tumor presented the typical aspects of a meningioma. It produced slight changes on the temporal bone, but before he discusses these he gives attention to some of the negative aspects. The membranous internal ear was free from changes. This indicates that even a considerable increase in cerebral pressure does not produce changes in the membranous internal ear, and that in a case of meningioma of the posterior cranial fossa normal aspects of the ear are possible. The saccus endolymphaticus was likewise free from changes, and the anatomic conditions indicated that the rigid connective tissue of the dura protected the saccus from the pressure of the tumor. This is important because it is still generally believed that a tumor of the posterior cranial fossa exerts pressure on the saccus endolymphaticus. In discussing the changes Fischer gives attention first to those on the cerebral termination of the cochlear aqueduct. He observed dropsy of the sheath of the glossopharyngeal nerve and an ampulla-like dilatation of the cerebral orifice of the cochlear aqueduct. Following a discussion of the significance of these changes, he considers the alterations in the region of the two pyramidal surfaces. On the anterior surface he observed numerous cerebral hernias at the typical sites. The changes on the posterior pyramidal surface are important because they throw some light on the relation between the dural endothelioma and the cranial hyperostosis. The question is whether a meningioma develops as a result of the irritation caused by an accidentally developing hyperostosis or whether the changes in the bone are a response to the endothelioma. Cushing found hyperostoses in 25 per cent of cases of endothelioma and is inclined to believe that tumor cells penetrate into the bone canals and irritate the osteoblasts. Fischer cites also the opinions of Unokawa, Schmidt and Erdheim and concludes that a hyperostosis developing over an endothelioma is at least partly the result of pressure on the dura and on the bone.

EDITOR'S ABSTRACT.

CERVICAL MEDIASTINOTOMY. E. WESSELY, Monatschr. f. Ohrenh. **69**:69 (Jan.) 1935.

Wessely's report is the introduction to a discussion of cervical mediastinotomy in the Vienna Laryngologic Society, and it is based on material from the laryngologic department of the clinic of the University of Vienna during the years from 1909 to 1934. After describing the method of cervical mediastinotomy, he discusses the incidence and etiology of the cervical phlegmons, records the incidence of phlegmonous cervical disorders in the various age groups and then analyzes the local and general conditions existing in the patients who underwent mediastinotomy. Further he gives attention to the complications on the part of the hypopharynx and the esophagus. Then he analyzes the material with regard to the time that elapsed before operation was resorted to and discusses the type of mediastinotomy. In the last part of his report he makes some remarks about the symptomatology of the inflammatory processes of the cellular tissue of the neck.

EDITOR'S ABSTRACT.

EOSINOPHILIA IN ALLERGIC CONDITIONS. GRIEBEL and DIMITROFF, Ztschr. f. Laryng., Rhin., Otol. (Teil 1: Folia oto-laryng.) **25**:327, 1934.

Following a brief review of the literature, Griebel and Dimitroff described their own clinical and experimental observations. They reach the conclusion that in the development of eosinophilia factors are active which are closely connected with ultraviolet radiation and with meteorological changes. These factors exert their influence by way of the sympathetic nervous system. Clinical as well as experimental studies indicate that the chemical action of the rays on the body surface produces active substances which enter the blood stream and then the bone marrow and here effect a flooding out of the eosinophils. The authors assume that the melanin-like bodies which produce pigmentation are the eliciting cause, the building stones, of proteins such as tyrosine, tryptophan, proline and hydroxyproline which provide suitable materials for the formation of melanin. Although some investigators have assumed that histamine bodies play a part, the authors think that they do not, since neither histamine nor the related derivatives produce a reaction. Moreover there is the possibility that the entire reaction takes place by way of the sympathetic nervous system, for irradiation with ultraviolet rays increases the irritability of the sympathetic nervous system and this would provide a common denominator for the meteorological influences. Moreover, the problem of eosinophilia involves the reticulo-endothelial system. The spleen intervenes as a regulator of the blood in cases of an increased as well as of a decreased number of eosinophils. However, this aspect of eosinophilia still involves a number of unknown factors.

EDITOR'S ABSTRACT.

Society Transactions

AMERICAN OTOLOGICAL SOCIETY

Sixty-Eighth Annual Meeting, Toronto, Canada, May 27-29, 1935

SAMUEL J. CROWE, M.D., *President, Presiding*

ABSTRACTED BY DR. ROBERT SONNENSCHEIN, CHICAGO

Monday Morning Session, May 27

PRESIDENTIAL ADDRESS. DR. SAMUEL J. CROWE, Baltimore.

Some of our members have made the criticism that the programs of this society are becoming too scientific and are "over the heads" of a large percentage of the audience. This may be a just criticism. Scientific investigation is a search for the truth, and the reward every investigator hopes for is that he will some day be able to make a discovery of great practical importance. A series of isolated facts gained by the arduous labor of a multitude of workers is gradually pyramided, eventually correlated by some one, and a new discovery announced to the world. This is the story of insulin, the thyroid, the parathyroids and the hypophysis. This is the only road by which advances in otology may be made. There must be some society in this country before which those engaged in scientific investigations of the physiology of the ear and the disorders of hearing can present their work. The logical one is the American Otological Society. If this society is to fulfil its obligations and justify its existence it must do everything in its power to stimulate and encourage all investigation that will broaden knowledge of the ear. Of equal importance to the society and to the investigators, however, is the fact that new work and new methods must be presented in a way that will educate and interest those of us who are engaged in active clinical work.

Your officers have given serious consideration to these criticisms and have adopted for this year the plan of asking a group of men engaged in scientific investigations of the ear to coordinate their work and present it in the form of a symposium, rather than as a series of papers on any subject in which they may be most interested at this particular time. The subject chosen for the first symposium of this kind is: "The Function of the Apical Turns of the Cochlea and the Symptoms of a Lesion in This Location." In June 1934 a letter was sent to the distinguished anatomists, physiologists and psychologists present today, outlining the plan for this symposium and asking if they would direct their work during the next year toward a solution of this problem and present their results at the 1935 meeting of this society. It is greatly to their credit and is evidence of the cooperative spirit of scientific men in this country that every man agreed to pool his work, even though it disrupted the plans for his own investigations. The answer to this question about the physiology of the cochlea, and particularly about the localization of low tones, is of great practical importance in the interpretation of clinical tests of hearing. The ultimate aim of all otologic investigation is to enable the clinician, by his tests, to visualize the exact location and nature of the lesion causing the impairment of hearing. It is of no value to make audiometric and tuning fork tests unless they can be intelligently interpreted.

Practically nothing is known about the location of the lesion causing a type of impaired hearing commonly encountered in otologic practice in which both low and high tones are involved, air conduction is better than bone conduction and perception by bone conduction is either much shortened or entirely absent. This

type of impairment is often ascribed to a "toxic neuritis" of the cochlear nerve. So far as I know, there is no histologic or pathologic justification for the diagnosis of "toxic neuritis." It may be that the "toxic" changes in the nerve are not visible under the microscope, but before accepting this explanation and the diagnosis of toxic neuritis every investigative method at our disposal must be utilized in an effort to learn more about this type of hearing defect.

SYMPOSIUM ON THE FUNCTION OF THE APICAL TURN OF THE COCHLEA AND THE SYMPTOMS OF A LESION THEREIN

Cochlear Localization for Low Tones: Studies of Human Material.

Stacy R. Guild, Ph.D., Baltimore.

Numerous theories of hearing and modifications of these theories have been published, and but few factual observations. The great need at present, in this field, is more facts; there has been more than enough theorizing. I shall limit myself to presenting evidence afforded by observations on the human being, and primarily to that obtained in the laboratory at Baltimore in attempts to correlate the records of hearing acuity with the structural conditions found in histologic preparations of the temporal bones.

The control group consists of over 200 ears from patients with good hearing, prepared by the same histologic technic used for those from patients with impaired hearing. Conditions found in ears with good hearing cannot be regarded as the cause of impaired hearing, when present in ears with impaired hearing.

Many ears with impaired hearing for low tones have histologically no lesions more severe than those in some of the control group. No evidence as to localization is afforded by the study of these ears or by the study of ears that were totally deaf or that have total atrophy of the organ of Corti or other type of destruction of the entire cochlea.

Crowe, Guild and Polvogt in their recent study of the pathologic changes causing impaired hearing for high tones have shown that all tones up to and including 1,024 double vibrations can be well heard by ears with total atrophy of as much as the basal one third of the total length of the organ of Corti and of the nerve fibers in the osseous spiral lamina to this region. From their evidence it cannot be concluded that the lower basal turn is incapable of receiving some or all of the frequencies up to 1,024 double vibrations; i. e., that the low and middle ranges of tones are normally dealt with only by the apicalward two thirds of the cochlea.

In an ear of the collection studied the apical and middle turns have been destroyed by an obliterative process, the upper basal turn has total atrophy of the organ of Corti, and only the lower basal turn is in condition to have possibly functioned. The hearing for 4,096 and 8,192 double vibrations agrees well with that which might be expected on the basis of the localization indicated by the study of high tone loss. The frequency of 64 double vibrations was not heard at the maximum intensity produced by the 2-A audiometer, and from 128 to 2,048 double vibrations, inclusive, the readings recorded may represent hearing through the head by the opposite ear, which was not "masked" in making the examination. The only positive evidence that any tones below 4,096 double vibrations were heard by this ear is that the "spoken voice" (probably loud) was heard by the patient at the same time that a Bárány Larmapparat was being sounded in the good ear. Since the essential tonal range for the understanding of speech is well below 4,096 double vibrations, this observation indicates that the lower basal turn can deal with at least part of the conversational range of tones. By no argument can it be concluded from a study of this case that low and middle range tones are as well heard via the lower basal turn as they are via the part of the cochlea above this level.

Another ear of the collection has an organ of Corti and nerve present only in the apical turn and the upper part of the middle turn. The test with the audiometer indicates that 64 and 128 double vibrations were heard by this ear at a loud intensity; the opposite ear was not "masked." The frequencies from 256 to 8,192 double vibrations, inclusive, were not heard by this ear at the maximum intensities produced by the 2-A audiometer. Certainly the two low tones, if actually heard by this ear, were not heard as well as they are when the atrophy is of the lower basal turn only.

Five ears have a circumscribed region of partial atrophy of the nerve supplying the lower part of the apical turn and the upper part of the middle turn; the organ of Corti is present in these regions. The hearing for low tones was within normal limits for 3 of these ears and moderately impaired in the other 2. The evidence from these 5 ears is not clearcut, but in a general way it seems to indicate that even a considerable degree of nerve atrophy, when limited to the upper middle and the apical turns, does not have much effect on the hearing acuity for low tones, and is distinctly not in agreement with the theory that there are sharply localized areas for the low tones.

Seven ears with defects in the bony septum between the middle and the apical turns had good hearing for the low tones, and most of them for high tones also. The same is true for several ears with persistent blood vessels that cross the scala tympani of the lower apical turn and arch up under the basilar membrane of this region.

The collection studied contains many examples of lesions of the lower basal turn in ears with impaired hearing for high tones, and but very few examples of lesions of the upper turns in ears with poor hearing for low tones. Also, for tones in the lower range of frequencies, it is rarely found that there is a great difference in the thresholds for tones an octave apart, while, for the higher tones, great differences are frequently observed for tones only a half octave apart. These general facts indicate that there is some essential difference in the way in which the human ear deals with low and high tones.

Partial section of the eighth nerve, as done by Dandy for the relief of the vertigo in Ménière's disease, also provides evidence bearing on the problem of tonal localization. In those patients in whom there has been any postoperative change in the range of tones heard, it is the upper limit that has been reduced—never the lower limit—and never is there a "gap" in the tonal range. The arrangement of the nerve fibers in the cochlear division is such that it is most improbable that in making incisions into one side of the nerve trunk the fibers would be divided in order from those supplying the basal end to those supplying the apical end of the cochlea.

ABSENCE OF THE ORGAN OF CORTI: AN AUDIOMETRIC AND HISTOLOGIC STUDY. C. C. BUNCH, PH.D., St. Louis.

Three cases are presented in which shortly before death the patients had varying degrees of auditory sensitivity. The histologic sections of the ears show degeneration of the organ of Corti throughout its entire extent. An unsuccessful attempt has been made to determine the causative agent. These findings are in agreement with those of earlier investigators who found that hearing was possible in the absence of the organ of Corti.

STIMULATION DEAFNESS AND ITS RELATION TO THE PROBLEM OF LOCALIZATION IN THE COCHLEA. E. G. WEVER, PH.D., Princeton, N. J.

After tests of hearing by the conditioned response method, three groups of guinea-pigs were stimulated for a prolonged period with an intense tone. Seven animals were subjected to a 1,000 double vibration tone of 125 decibels (above the human threshold) for 110 hours, 6 to a 1,500 double vibration tone of 100 decibels

for 2,000 hours, 1 to a similar 1,500 double vibration tone for 1,070 hours, and 4 to a 3,000 double vibration tone of 100 decibels for 1,250 hours.

Tests by the conditioned response method, made after the exposure period, showed considerable losses of acuity in all the animals. These losses were not specifically related to the frequency of exposure but were general in character.

After a period of time, the sensitivity of the cochleas of 5 of the animals was measured by the electrical method. An electrode was placed on the round window, and the electrical impulses produced during stimulation of the ear by sound were studied, after suitable amplification, by means of a cathode ray oscillograph.

The results agree with the acuity tests in showing a loss of hearing, which in some cases was significantly greater than that revealed at the time of the acuity tests. In these tests also the loss of sensitivity was found to be general rather than specific. The results, therefore, do not indicate any precise localization of the response of the cochlea to tones of high intensity.

THE LOCALIZATION OF PITCH PERCEPTION ON THE BASILAR MEMBRANE. DR. HALLOWELL DAVIS, Boston.

The electrical potentials generated in the cochlea of the guinea-pig were picked up by electrodes placed on the round window and the neck, and were studied by means of a cathode ray oscillograph. These potentials are a good indicator of the ability of the animal to hear because (1) they are absent in deaf animals, (2) they have thresholds which correspond closely to the threshold of hearing in man and also in guinea-pigs tested by the method of conditioned reflexes, and (3) equal potentials are produced at different frequencies by the same strengths of stimulation as yield tones judged equal in loudness by human observers.

Electrical audiograms were taken before and after drilling through the cochlear wall and damaging the organ of Corti at various levels. The exact location and extent of each lesion were determined by subsequent microscopic study of serial sections of the cochleas, and these were correlated with the losses in hearing revealed by the audiograms. The losses in most cases were not greater than from 20 to 30 decibels and sometimes were definitely limited to one or two octaves. Sometimes hearing was depressed for all tones below a certain limit. The best correlations could be obtained between the boundaries of the lesions and the first deviations from the control in the audiogram. In 20 animals a consistent correlation of this sort was obtained. High tones are localized near the basal end of the cochlea; 2,000 cycles per second is at the middle, and the low tones, to which particular attention is directed, are bunched quite closely toward the helicotrema—more closely than has previously been supposed.

A tone 20 or 30 decibels above threshold apparently activates a considerable zone of the organ of Corti, but this fact does not in any way contradict the fundamental localization described in the foregoing paragraph.

A striking feature of these results is the indication that the resonant area for each particular tone is located in the ear of the guinea-pig in the same relative position as in the human ear when the human location is determined by graphic integration of the most recent data for differential sensitivity to pitch. The same close grouping of low tones near the helicotrema appears in both cases.

AN EXPERIMENTAL STUDY OF LESIONS OF THE COCHLEA. DR. WALTER HUGHSON, Baltimore.

In a large series of experiments carried out on over 100 animals in the past three years, the function of the organ of Corti in the apical turns of the cochlea has been studied. Animals have been operated on under aseptic technic, the apical turns damaged and the animals allowed to survive for varying intervals of time thereafter before testing. Acute experiments have also been done in which tests were made immediately after destruction of the organ of Corti. A series of animals with spontaneous atrophy of the organ of Corti were also studied. The

electrical method of obtaining audiograms of the cats' ears has been used in all experiments. In addition to direct damage to the organ of Corti, long exposure to tones of high intensities and experiments with detonation have been carried out. All experiments were controlled by histologic sections of the ears. When necessary, electrodes were placed on the round window rather than on the auditory nerve in order to demonstrate beyond doubt that certain frequencies were or were not transmitted. Failure to transmit any given frequency, no matter what intensity was used to stimulate the ear, was regarded as evidence of loss of function.

Conclusion.—No evidence obtained from the procedures described indicates localization of low frequencies to the apex of the cochlea. Though the apex is doubtless necessary for optimum experimental transmission or clinical perception of tones, any intact portion of the end-organ may serve as the receptor of a stimulus of low frequency applied to the ear.

THE LOCALIZATION OF PITCH IN THE COCHLEA. T. H. BAST, PH.D., Madison, Wis.

With the Wever and Bray method, the ears of guinea-pigs were studied for localization of pitch. Tone frequencies ranging from 50 to 4,000 cycles per second were carried into the ear by an audiofrequency oscillator. The electrode was placed first on the apex of the cochlea and the pick-up recorded by means of a swinging coil galvanometer. Then the electrode was placed on the basal turn of the cochlea and readings made for the same frequencies. Graphs plotted from these readings show that low frequencies are picked up much better from the apical turn and high frequencies better from the basal turn of the cochlea. These results must be interpreted as showing that the localization of the high frequencies is in the basal and that of the low frequencies in the apical turn. That this localization, however, is not absolutely specific is noted when the apical half of the cochlea is removed. In this case the transmission of low frequencies is markedly reduced but not in all cases obliterated. The specific structure in the cochlea responsible for the production of the streaming potential, which one picks up, has not yet been determined. My associates and I have shown, however, that it is not the organ of Corti, for good conduction is possible when the organ of Corti is atrophic and fibrosed. Lantern slides of the histopathologic aspects of these ears and graphs of the conduction results were shown.

QUANTITATIVE STUDIES OF HEARING IN CATS. DR. SIMON DWORKIN, Montreal, Canada.

Hearing acuity has been investigated (*a*) in normal cats, (*b*) in cats after damage of the middle ear and (*c*) in cats after damage of the cochlea. The work is not yet complete. The studies have been confined to frequencies between 100 and 16,000 cycles per second. Undoubtedly, however, the upper limit of hearing in cats is as high or higher than 30,000 cycles per second. Laboratory animals must be (*a*) thoroughly conditioned, (*b*) in perfect health and (*c*) fairly but not too hungry. An unexpected difficulty developed in what might be termed a "neurosis." Several days' rest was necessary to procure recovery. The animals were also conditioned to light and to tactile stimuli for two purposes: (*a*) to lessen the nervous tension of waiting between threshold stimuli and (*b*) to provide a check when hearing seemed absent. Thus, when the sound was too weak to be heard and yet the light stimulus brought out a response, it was clear that reactivity was not impaired. In those tests in which hearing was impaired, the additional stimuli were useful as controls.

In cats only one ear was used, the other being completely deafened. This hearing (monaural) was compared with the hearing in young healthy students (binaural). These studies show that for lower frequencies (100 to 3,000 cycles) the cat's hearing is about the same as that of man. The results agree with those of Sivian and White in showing greatest sensitivity between 2,000 and 3,000 cycles. This point of maximal intensity was plotted as 0 decibels. At 5,000 cycles the

threshold for man rises appreciably; at 10,000 cycles it is 22 decibels plus; at 14,000 it is from 50 to 60 plus; the sensitivity in cats is lowest between 5,000 and 10,000 cycles. From this lowest point the rise is very gradual. At 16,000 cycles the threshold for the cat is never more than 14 decibels above the most sensitive point. One may conclude, therefore, that for the upper frequencies the hearing of the cat is much more acute than that of man.

The operations on the middle ear or the cochlea were done under strict asepsis, and the approach was through the mastoid bullae. The accessory structures of hearing were put out of function (such as the incus and the malleus, with perhaps damage to the stapes or the oval window). In this middle ear deafness the audiogram was very similar to normal. The changes of sensitivity for different frequencies do not seem to be the function of the accessory mechanisms of hearing; but, for all frequencies the sensitivity is, as expected, greatly diminished. At 10,000 to 14,000 cycles, therefore, the hearing of a cat without ossicles is reduced to that of man.

It was not possible to produce localized tone loss in the cochlea itself, although the experiments were carried out on 12 well trained animals. In all these animals damage to the cochlear apex produced complete deafness. Later these same deaf animals could be conditioned to loud musical sounds, so loud as to produce palpable tremors. So far as they go, the results argue against localization of low tones in the apex of the cochlea.

THE FUNCTION OF THE COCHLEA FROM THE POINT OF VIEW OF ANIMAL EXPERIMENTATION. E. A. CULLER, PH.D., Urbana, Ill.

In connection with this symposium, I have concentrated on two problems: (1) Is the electric response of the cochlea to a given frequency focalized at some point of maximal activity? (2) If so, where are these foci? Certain methods frequently employed hitherto (drugs, cauterization, drilling, stimulation deafness) seemed undesirable. In addition to the lengthy, laborious and difficult procedures associated with adequate histologic examination, these methods all introduce variable and unknown changes into the physical characteristics of the cochlear system. It seems clear that a mechanism intact from tympanum to nerve must be studied if one is to learn what normally happens. A sharp needle-electrode was placed on selected points of the guinea-pig's cochlea and the response measured for some twenty-three frequencies throughout the audiorange. By collating these responses I secured a map of the cochlea giving the locus of each representative frequency from 60 to 7,000 cycles. From the round window, the first (basal) turn comprises the foci for frequencies from an undetermined upper limit down to about 2,800 cycles; the second turn, those for frequencies on down to about 875; the third turn, for those down to about 260; the fourth turn, for those down to about 75; the final half turn, for the frequencies below 75. Slides are used to elucidate the method and the completed map of the foci for the twenty-three frequencies. From these observations it seems legitimate to infer that each frequency has a locus, as revealed by the electric energy therein generated, whatever may be the precise nature of cochlear response.

THE FUNCTION OF THE COCHLEA FROM THE POINT OF VIEW OF CLINICAL OBSERVATIONS. DR. MAX A. GOLDSTEIN, St. Louis.

The Helmholtz theory has not as yet been disproved, so that one cannot definitely accept a new theory of cochlear function. Recently, laboratory workers through experimentation have concluded that tone frequencies over 2,000 double vibrations are beyond the capacity of transmission by nerve fibers. However, it seems to me illogical to measure tone frequencies below 1,000 by one standard, and those above by another. Experimentally it has been found that different parts of the cochlea are connected with different nerve cells and pathways in the brain stem. Thus, impulses arising in the cochlea are accompanied by a local sign indicating in which specific point they were produced. Thus, differentiation of

tone appears to be based on a space design. Other workers have found that the frequency of impulse produced in a nerve fiber is based on the strength of the stimulus. This is true for all sense organs—tactile, muscular, visual, chemical, etc. Thus, the organ of Corti, which is a selective tactile organ, will produce in the acoustic nerve fibers trains of impulses of different frequencies according to the intensity of the tone. Tone frequency, then, will not be recognized by the frequency of the nerve impulse because increase in intensity will change the frequency of the impulse.

The experiments of Wever and Bray do not refer to a single fiber but rather to the whole nerve trunk. When there is asynchronism of different fibers there is interference of the potential waves; thus one cannot conclude that conduction of sound through individual fibers takes place as recorded for the whole nerve trunk. I believe, therefore, that it would be desirable if impulses conducted by single fibers of the cochlear nerve could be observed and measured.

Thirty years ago Bezold, after painstaking tuning fork tests, announced the presence of tone islands in the organ of Corti. These tone islands were found in congenitally deaf children with residual hearing and in persons deaf following scarlet fever, measles, etc. Later, workers have found partial obstructions in the Corti scale in aural conditions following such infections or in congenital deafness with hearing residuum.

In my own work I have been able to demonstrate marked improvement in an impaired tone scale by intensive training, but I believe this is due to improvement in the central analysis of tone. Such islands of hearing seem to indicate that there is a definite projection of the tone scale in the basilar membrane.

Recent work has established the projection of the high tones. It is hoped that extension of the work will show the same conditions for the low tones.

AN EMBRYOLOGIC APPROACH TO THE PROBLEM OF LOCALIZATION OF FUNCTION IN THE COCHLEA. DR. EDWARD MCCRADY JR., Philadelphia.

It is shown that the embryology of the membranous labyrinth in the opossum is like that in man except for the relation to the time of parturition. When the opossum is born the cochlear duct has grown out only one-half turn. In man this stage is reached in the fetus at six weeks. In a sense, therefore, it may be said that nearly six sevenths of the embryologic development of the ear in the opossum occurs after birth. This fact enabled Dr. Larsell and me to study the development of function at the same time that we studied the development of structure and to correlate the two. The gist of the evidence from this study may be summed up as follows: The receptor mechanism is an elongate structure. During development it does not differentiate simultaneously throughout its length, but one region nearer one end differentiates first and the process of differentiation spreads from this point in both directions. If function depends on the completion of the receptor mechanism, and if there is localization of pitch reception along this linear structure, it must be expected that the function of hearing does not develop simultaneously for all ranges of pitch, but that notes nearer one end of the adult range must be audible first, and later the range of hearing must spread in both directions. This is exactly what happens. Our experiments show that at first the opossum can hear only one note (1,305 double vibrations), a rather high note in the third octave about middle C. The organ of Corti at this time is finished only in the second half of the basal coil. Subsequent extension of the range of hearing follows the differentiation of the organ of Corti in other coils of the spiral. These results support the theory that for moderate intensities there is localization of function in the cochlea, and that the highest notes are received near the base and the lowest notes near the apex.

In summary the evidence is as follows: The receptor mechanism is an elongate structure. It does not develop simultaneously along its length; one region nearer one end differentiates first, and the process of differentiation spreads from this point in both directions. Notes nearer one end are audible before other notes, and the

range of hearing subsequently spreads in both directions. My associates and I therefore believe that there is localization of function within the cochlea, and that the highest notes are received near the base and the lowest notes near the apex.

Is There Localization of Low Tones in the Cochlea? Dr. Edmund Prince Fowler Jr., New York.

It is important to determine whether or not there is localization of low tones because of the physiologic and clinical implications. Opinions differ largely according to the interpretation of terminology, physical background, hypothesis and clinical evidence.

To contribute something constructive from clinical evidence is impossible without a physical background, because the essence of localization is physical. Definitions are given of what is meant by localization and by a low tone, and why the frequencies below 1,000 are logically thought of as low tones.

The basic cochlear physics are considered step by step, starting with zero frequency via the stapes and gradually increasing. Even with zero frequency there is a localization effect. Changes caused by closure of the helicotrema and of the oval and round window are described, and seem to apply no matter what size the cochlea may be, or in what animal. I cannot conceive of a total lack of localization even if there is a rudimentary cochlea or no cochlea. Even a lump of mud will have some localization because it will vibrate in different parts differently for the different frequencies.

A point is made of the fact that increases in amplitude of stapes movement and increases of frequency produce several similar effects, viz.: 1. Both increase pressures in the cochlea and cause an increase of shunt release through the basilar membrane. 2. Both give a sensation of increase in intensity. 3. Both give a sensation of increase in pitch.

Bone conduction is discussed along the same lines as air conduction, and means for making it more reliable are detailed. It is no more unreliable than air conduction, and it has one great advantage over air conduction; that is, at threshold, bone conduction is less influenced by masking noises. Without bone conduction diagnosis is unreliable. Although in the aged patient bone conduction is usually diminished, so also is air conduction. Physicians do not allow for the fact that, as usually employed, forks are heard only somewhere near one-half as long by bone conduction as by air conduction, and that audiometrically their intensity range is seldom greater than 65 decibels. A plea is made for using the same base line for measuring air conduction and bone conduction, and for the use of the same units of measure.

Ideas to the contrary notwithstanding, no matter how rapid or how slow vibrations are, each one is still a pulsation, a push and a pull, a to and fro, or oscillating, movement in the vibrating mediums. Starting with the statement that by bone conduction the whole wall of the labyrinth is acting as a pump, the different physical changes are set forth with their effects on localization in the cochlea. Both windows of the cochlea serve to relieve pressure in the labyrinth and thus allow movement of the basilar membrane. The variations in flow depending on which window or windows are functioning or not functioning are described.

Clinical and experimental observations are quoted to substantiate the theoretical evidence; it appears that the basilar membrane moves in exactly the same way for air conduction and for bone conduction.

The standard diagnostic criteria are set down and certain conclusions drawn therefrom. The hypothetic background regarding localization on diaphragms and on the basilar membrane, which is considered as a pie-shaped section from a round diaphragm, is discussed, as well as the change in localization areas in amplitude and the binaural localization of sounds. Changes with pressure are mentioned particularly, to stress the fact that the oval and round windows not only serve to relieve pressures in the cochlea but also act as pressure release port for the

vestibule and semicircular canal. It is contended that in some cases of markedly impaired hearing with frequently recurring vertigo not only the deafness but also the vertigo may be accounted for by ankylosis of the stapes or closure of the round window, both of which interfere with sudden changes of pressure. Clinically, the vertigo would be intermittent, and certain diagnostic differences would be noted in the air and bone conduction tests. The labyrinthine tests would be normal.

Much clinical evidence is detailed showing differences between the low as compared with the high tones. In abnormal ears bone conduction gives a truer picture of cochlear function than air conduction, and the differences as revealed by the hearing tests and graphs do not lead to the conclusion that there is no localization for the low tones, but to the opinion that they are localized under different conditions.

It is difficult to prove directly that there is a localization for low tones, but the absence of pathologic confirmations of clinical findings is not a valid reason for believing that there is no localization, even though the pick-up from the basilar membrane may be dependent on some physical phenomena other than localization. In closing, it is pointed out that even if localization has nothing to do with the physiology of hearing there is nevertheless a localization of low tones in the cochlea.

DISCUSSION

Dr. Harris P. Mosher, Boston: I have never done anything which I regretted more than having allowed my name to appear on this program as a discusser of this symposium. I know that I have nothing to say on the subject, although I was much interested in the symposium. I suspect that Dr. Guild's discovery of 1 case to prove his point was the real reason why the whole thing was started. In reviewing what has been said in this meeting, it seems to me that both sides have won. It is one of the most splendid scientific symposia to which I have ever listened. I think I have never heard such a series of honest and sharp presentations.

Dr. John C. Steinberg, Bell Telephone Laboratories, New York: I shall consider cochlear localization from the physical point of view. When one hears a moderately loud 50 cycle pure tone one hears as well harmonics of this tone—100, 150, 200, 250 cycles, etc. These harmonics are introduced by the ear itself. They are called subjective harmonics. This phenomenon is supposed to be due to overloading of the transmitting mechanism. One measures these harmonics by introducing a search tone. For a tone of 100 cycles, one uses a search tone of 103 cycles. If a subjective second harmonic is present, a beat note of 3 cycles will be heard. Any tone below 1,000 cycles will produce noticeable subjective harmonics when its level is 50 decibels or more above the normal threshold. It is evident then that pure tones in the air do not mean pure tones in the ear. They may be localized but are very faint when of low frequency. Harmonics are heard before the fundamental. Thus, hearing loss as ordinarily measured does not always measure hearing loss in a localized area of the cochlea.

Is impaired hearing for the tones below 1,000 ever due to a lesion of the cochlea or of the inner ear? I believe one should measure hearing loss for sounds above the threshold, instead of at threshold, as is done now. If nerve deafness means the loss of a given number of active nerve fibers and conductive deafness means a loss or attenuation in the intensity of the sound wave, measuring the hearing loss for sounds that are 20 or more decibels above the threshold will yield one audiogram for nerve deafness and a different audiogram for conductive deafness. Thus, the test serves to differentiate nerve deafness and conductive deafness.

Dr. Emil Amberg, Detroit: A few years ago, at the meeting of this society in Washington, D. C., Dr. Lurie of Boston reported his investigations concerning the development of the cochlea in a certain lower animal. He showed that the cochlea developed from two distinct portions. This would prove that the ear consists of three organs and not of two.

Tuesday Morning Session, May 28

SYMPOSIUM ON CERTAIN FUNDAMENTALS IN REGARD TO SUPPURATION OF THE PETROSAL PYRAMID

INTRODUCTION. DR. SAMUEL J. KOPETZKY, New York.

This symposium is held in an endeavor to clarify many of the moot points in regard to infections of the petrosal pyramid. In opening the discussion, I shall stress the necessity of stating the problems which confront us.

The lesions are the result of tissue reactions to bacteria and are dependent on the character of the bone structure on which the lesions develop. Dependent on this, either osteomyelitis or coalescent osteitis is found.

The failure to comprehend the existence of these two types of lesion in the petrosa has led to much of the confusion which prevails in the understanding of the problems.

There is a difference in the clinical pictures of osteomyelitis and coalescent osteitis of the pyramid, so that differentiation is possible both clinically and roentgenographically. There are two types of osteomyelitic lesion: (*a*) the hematogenic and (*b*) the otogenic. The pathologic aspects of both types have been known since the early part of the century.

The otogenic type of osteomyelitis occurs after the acute phase of an otitic infection has subsided. In osteomyelitis the pain, in contradistinction to the retro-orbital and infra-orbital manifestations in osteitis, is usually auricular, periauricular or hemicranial. The understanding in regard to the significance of the Gradenigo syndrome is noted; it is not pathognomonic for a lesion in the petrosal pyramid. Dependent on the time when the lesion is recognized clinically, a subdivision of the lesion is possible; the lesion may be designated as intrapetrous on the one hand and peripetrous on the other. In the first designation, the lesion is diagnosed from the evidence which it presents before endocranial extension, and in the second has extended to the various surrounding tissues, nerves, blood vessels and muscle strata, most of which give clinical manifestations of concomitant involvement.

In many of the cases symptoms are present denoting an involvement of the petrous bone, but the bone gets well with no further surgical intervention than a well performed simple mastoidectomy. Others, when studied, give evidence which leads to the discovery of a fistulous tract which is also reachable without resort to radical mastoidectomy. Then there are cases in which there is a tract opening at the tubotympanic orifice, which can be reached only after radical mastoidectomy. Finally, there are the cases of encapsulated empyema, with their threat of intracranial invasion, which require specialized technic in order that the empyema may be reached and evacuated.

Attention is called to the misuse of the term "conservative treatment" as being unscientific, because any treatment is conservative which reaches and eradicates the lesion in the shortest and most direct way. The routine use of specialized technic is a blunder.

The following questions are now submitted:

1. Can osteitis be differentiated clinically from osteomyelitis of the petrous bone? On what shall diagnosis depend? What rôle shall roentgen examinations play in the determination of diagnostic factors?

2. Is the triad of pain from the vidian nerve, continued otorrhea or a reappearance of otorrhea after a period of cessation, and a low grade sepsis common to all types of petrositis? If not, to what particular types does this triad of symptoms apply?

3. Do lesions in different portions of the petrous bone give characteristic symptoms of sufficient import to enable one to localize the site of the lesion preoperatively?

4. Does one need a more exact nomenclature to describe the lesions in the petrous bone, so that advocated technic may be better understood?

5. What shall be understood by "conservative treatment"?

6. Since it is possible to diagnose the lesion during the stage designated as "intrapetrosal," is it considered "conservative" or proper to institute surgical measures which attack the lesion through peripetrosal areas?

7. Since there are obviously types of petrosal involvement, and varying localizations of the site of the lesion, are all types and all sites amenable to one type of therapy? Let otologists specify the type and location of the site of the lesion to which a given therapeutic measure is applicable.

8. At which time in the development of the lesion does surgical intervention become necessary?

9. What are the hearing and other end-results in proved cases of petrosal infection when only simple mastoidectomy is performed?

NORMAL ANATOMY AND HISTOLOGY OF THE PETROUS PORTION OF THE TEMPORAL BONE. STACY R. GUILD, PH.D., Baltimore.

The extremely wide range of "normal" variation of the adult human petrous pyramid (pars petrosa of the temporal bone) is stressed. Lantern slides made from photomicrographs of histologic sections are shown to illustrate the following facts:

1. Some petrous pyramids have extensive complete pneumatization—the cells may be large, small or medium-sized; some petrous pyramids have no pneumatization beyond the limits of what are commonly regarded as the middle ear and the eustachian tube; every possible intermediate degree of pneumatization occurs.

2. The structure of nonpneumatized pyramids and of the nonpneumatized portions of partially pneumatized pyramids is also variable. They may consist of cancellous (spongy) bone with the spaces almost entirely occupied by hematopoietic (red) marrow or by an almost pure fatty marrow or by a mixture of these two types of marrow; or they may consist of solid, dense bone with only a very small amount of marrow.

3. The petrous pyramid is frequently made up of a mixture of all of the structural features which are sometimes present alone: pneumatized spaces, solid bone, cancellous bone with red marrow and with fatty marrow, in every conceivable irregular arrangement within the limits of the surfaces of the bone.

4. The structural elements themselves, no matter how arranged, do not differ in any way from the same kind of structural elements in other parts of the body. Histologically the marrow in the spaces of the cancellous bone of the pyramid is indistinguishable from the corresponding types of marrow in other parts of the body. The walls of the air-containing cavities of the petrous pyramid are indistinguishable histologically from those of the mastoid region. In both regions the pneumatic cells, when present and normal, have a very thin mucosal lining (or mucoperiosteum) that consists of a scantily vascularized fibrous layer covered by a simple squamous epithelium (i. e., a single layer of flattened cells).

5. Pneumatized spaces in the petrous pyramid may and do originate from four primary regions: the osseous portion of the eustachian tube, the hypotympanum, the epitympanum and the mastoid antrum.

The relations of the large number of functionally important structures that either pass through or are in contact with one part or another of the petrous pyramid are considered from the point of view of applied anatomy. Emphasis is placed on the idea that the region is so rich in relations that, by a complete appraisal of all positive and all negative clinical and physiologic observations that can be made, it should be possible to localize any active pathologic process in the petrous pyramid rather exactly. No one has yet, in making a diagnostic study, taken full advantage of all the possibilities afforded by the numerous anatomic relationships of structures in and near the petrous pyramid.

ANATOMY. DR. MARVIN F. JONES, New York.

The pathology of the pneumatized pars petrosa of the os temporale presents a few controversial phases. Although disease causes tissue changes in the petrosa which are comparable to the tissue changes in bony structures elsewhere in the body, certain features of petrositis resemble no universally recognized pattern. Various theories have been advanced to explain unusual tissue arrangements, and many of these theories have been accepted as facts without sufficient corroborative evidence. Recognizing that the whole subject of petrositis is in the phase of development, Dr. Crowe sagaciously suggested that remarks be limited to personal observations and experience. Reference to former work will therefore be omitted.

More thorough study of pathology as applied to the petrous process will tend toward clarification of the problems presented by unresolved cases of purulent otitis and their complications. Persistent aural discharge accompanied by headache, vertigo, nausea, vomiting, impaired hearing, neuralgia, paralyses or, in addition, any other symptoms which may indicate the escape of infection from the confines of the petrous cells creates a puzzling situation. A more complete understanding of petrous anatomy and pathology will aid in the final solution.

Dr. Guild has demonstrated the proof of his assertion relative to the analogy between the anatomy of the pars petrosa and the pars mastoidea. If his deductions are accepted, it follows as a logical assumption that when the same invading organism involves the anatomic structures which he describes the same pathologic changes will result. The specimens examined from the collection in Dr. Crowe's laboratory at Johns Hopkins Hospital and from that in Dr. E. P. Fowler Jr.'s laboratory at Columbia University and those prepared by Dr. Hemsath in my own laboratory at the New York Post-Graduate Medical School and Hospital show some proof of this assumption. The specimens to be presented are from the collections of Drs. Crowe, Guild and Fowler Jr. They exhibit similar pathologic changes in the pneumatized petrous and mastoid portions of the temporal bone.

Dr. Guild has mentioned the difficulties he has encountered with anatomic nomenclature. I have encountered the same difficulties in pathology. To avoid confusion, the nomenclature in common use by otologists will be adopted rather than the more scientifically exact, but to most otologists, less comprehensive nomenclature of the pathologist.

The incidence of pathologic conditions in the pneumatized petrous bone has little statistical significance without accurate information regarding the incidence of partial pneumatization. While complete pneumatization is, undoubtedly, a very rare occurrence, partial pneumatization is not uncommon. Microscopic examination of hundreds of temporal bones is essential before accurate percentage tables can be compiled. Earlier experience gave the impression of the occurrence of pneumatization in about one third of all cases, but recently 16 adult temporal bones were seen in my collection without finding a pneumatic cell in the antelabyrinthine region. Various percentages have been proposed based on gross examination or the roentgenogram. Microscopic examinations prove these estimates to be inaccurate. A small percentage of petrous bones have pneumatized petrous cells. Of this small number, few present petrositis. Of the patients with infected petrous bones, only an occasional one dies. From the small number who die a very small proportion of petrous bones are obtainable at autopsy. The small number of specimens obtained from the large clinics at Johns Hopkins Hospital, Columbia University and the New York Post-Graduate Medical School and Hospital during the past few years is an indication of the element of time involved before knowledge of the pathologic changes will be definite.

Nearly all cases of middle ear infection present accompanying inflammation in the mastoid. As the cellular petrous bone bears the same or, perhaps, a more intimate relation to the middle ear cavity, it is reasonable to assume that when the middle ear becomes inflamed the contiguous petrous cells also are coincidentally involved. Therefore, many cases of petrositis must resolve following a simple myringotomy. By the same process of reasoning, if the mastoid process is the seat of infection, the cells extending into the petrous process being structurally the

same and continuous, petrositis is of necessity an accompanying feature. Obviously, an adequate simple mastoidectomy must, in most cases, effect a resolution of the petrous involvement. It is evident that the pneumatized petrous portion must be frequently involved, and just as evident that the involvement usually subsides following adequate surgical drainage.

Chronic infections follow the same general routes as acute involvement. We have, in addition, the artificial pathways formed by bone destruction. This destruction may involve bony trabeculae, causing coalescence of pneumatic cells, or it may break the confines of the pneumatic cells or the confines of the pneumatized spaces and invade the bone marrow cells. Adequate radical surgical treatment of the mastoid usually effects adequate drainage for cure of the chronic conditions. The type of case considered most dangerous is that of an acute infection superimposed on a chronic or prolonged process. Here a number of factors combine to permit the entrance of a new organism into a previously formed cavity and at the same time to obstruct free drainage for the new-formed pus. The original pathway may be obstructed by swelling of the lining membrane, by desquamated bony and epithelial detritus, by fibrous tissue bands or adhesions, and sometimes the consistency of the discharge itself impedes drainage.

The histologic sections reproduced contain evidence to support the statements offered in the text.

PATHOLOGY OF THE PETROUS TIP. DR. J. GORDON WILSON, Chicago.

The petrous tip lies medial to the internal auditory meatus and the bony capsule of the cochlea and terminates at the synchondrosis of the basioccipital process and sphenoid. Its apex is inserted into the angle between the occipital bone and the sphenoid, leaving an irregular chink (foramen lacerum medium) filled with fibrocartilage. The inferior part constitutes part of the under-surface of the base of the skull and is in close relation to the canal of the internal carotid artery, which canal encloses sympathetic nerves and a plexus of veins communicating freely with the veins of the tympanic cavity.

My study is based on an examination of the petrous tip in 50 children aged from 5 weeks to 15 years. In half the cases, the extreme tip had been removed and the bone prepared for other investigations, but in all there was present the area medial to the cochlea and the internal auditory meatus, comprising half the tip. Symptoms of petrositis are, in my experience, most common between the ages stated. As the petrous bone develops it changes in size and position with corresponding changes in the skull. Thus, the auditory capsule becomes slightly displaced toward the base. In the adult, the length averages one and one-half times that in the infant, and its width is doubled. During development, the petrous bone is the pivotal part of the floor of the skull. It is subject to the strains, the directions of which are indicated by the trend of the trabeculae. In contrast to the membranous labyrinth with its primary osseous capsule, which remains unaltered in size after birth, the petrous tip undergoes marked increase in size owing to bone formation under the periosteum and owing to growth between the otic capsule and the basioccipital process and sphenoid. The spaces between the trabeculae which contain marrow cells widen. In young bone one finds the red variety of marrow; in the adult, the yellow (fatty). Increase in red marrow is due to irritation, either local or elsewhere in the body.

The petrous marrow receives its blood supply from the arterial plexus in the carotid canal, from the dura and from the tympanic cavity.

In that part of the petrous bone lying medial to the primary osseous capsule of the labyrinth, a secondary circular deposit of bone is formed external to the primary osseous capsule but of different histologic character. These bone deposits are, in youth, separated by wide marrow spaces which diminish and almost disappear with age. The secondary capsule is compact toward the cochlea but medially has trabeculae forming cancellous bone. In the young, the trabeculae are close but become wider apart later. The marrow spaces communicate freely. In developing bone osteoclasts are seen.

Pneumatic Spaces.—The question of pneumatization has become important because the surgical treatment of inflammation in marrow spaces is not identical with that of inflammation in pneumatic spaces. Infected pneumatic spaces may be curetted and broken down. This is not so of infected osteomyelitic areas. Diagnosis of a pneumatic space can be made only microscopically. In the developing mastoid the bony walls of marrow spaces adjacent to an air cell break down, and the epithelium from the air space invades the cavity, displacing the marrow, to form a pneumatic space. This is true for the eustachian tube. Pneumatic cells of the petrous tip must develop from mastoid cells lying close to the floor of the skull. In children, pneumatic cells are often found external to the internal auditory meatus, close to, and even internal to, and above the semicircular canals. These are mastoid cells which have become diploetic at the base of the skull. They are often involved in mastoid suppuration, but there is a solid labyrinthine bony wall which separates mastoid cells from the petrous tip, forming a barrier to the progression of air spaces. Pneumatic cells also exist in the apical region. Gradenigo found them in most cases presenting his syndrome.

Petrositis.—This is a localized osteomyelitis, usually associated with pathologic changes in the middle ear. The marrow cells filling up the interstices of bone are much increased, and serous effusion can be noted. The calcified tissues become involved and show signs of necrosis. The early signs are similar to those of any acute infection—engorgement of blood vessels, exudation of serum and emigration of red and white blood corpuscles. Pus and granulation tissue appear, and the necrotic bone of the trabeculae is absorbed, leaving an abscess cavity, which may be small or may involve a large part of the tip. As the chronic stage subsides, the cavity may persist and become filled with granulation or fibrous tissue. The pus may remain for an indefinite period or may be replaced by serous exudate with a gross appearance similar to a small cyst. Exudate may be replaced by granulation and then by fibrous tissue. Periosteal bone may stay until a late period, but if disease persists, this bone becomes thin and necrotic till finally there is a fistula with escape of pus.

There is diversity of opinion as to the common routes of invasion. It may be by the blood stream or a variety of other channels. I have found it to occur frequently by the vascular channels and lymphatics from the middle ear.

The disease may be acute, subacute or chronic, often with acute exacerbations. In petrositis, as in mastoiditis, there may be nonsuppurative inflammation. If there is necrosis, a fistula with pus may form at any point. A petrositis may be part of a general osteomyelitis, as that occurring with an osteomyelitis of the tibia, with the middle ear and mastoid normal.

Bacteriology.—There is no agreement as to the causal organism. Streptococcus, Pneumococcus and B. coli have been found. Usually the organism has been obtained from the middle ear or mastoid. Sometimes septic organisms enter the blood stream and remain dormant until some cause, such as a depression of health, excites them to activity.

In petrositis, as in all infective processes, the marrow cells are greatly increased. The proportion of myelocytes is much increased. Since the marrow cells are part of the reticulo-endothelial system, it is a defensive mechanism which ought to be considered in the treatment of clinical cases.

CORRELATION OF ROENTGENOGRAPHIC AND PATHOLOGIC OBSERVATIONS IN SUPPURATIONS OF THE PETROUS PYRAMID. EDMUND PRINCE FOWLER JR., New York.

It is suggested that the "petrous tip" of surgeons and roentgenologists be called the "surgical petrous tip" or "surgical apex" in contradistinction to the anatomic petrous tip described in the textbooks of anatomy and of otology. The term "petrositis" should be used to indicate inflammation in the petrous pyramid medial and anterior to the arcuate eminence; that is, it should include suppurations in the perilabyrinthine as well as the antelabyrinthine regions.

The petrous pyramid is difficult to study by means of x-ray films because of its depth within the skull and because of variations in its anatomy. Partial pneumatization of the petrosa is the rule in microscopic serial sections, but the cells are usually not apparent in roentgenograms because of superimposed sclerotic or diploic bone. Extensive pneumatization can be seen in roentgenograms but may be difficult to localize unless a number of projections are made.

In a series of 9 patients who died with petrositis there have been infected cells along the superior angle, and in some of the patients these were the only pneumatic cells present in the petrosal pyramid.

A plea is made for the recording of the technic used for comparison plates, so that subsequent changes in density can be more accurately evaluated.

Roentgen evidence of pathologic change does not necessarily mean operative petrositis, and apparent absence of pathologic change in x-ray plates does not necessarily mean that there is no petrositis present.

THE CLINICAL PICTURE OF SUPPURATION OF THE PETROSAL PYRAMID. DR. ERNEST M. SEYDELL, Wichita, Kan.

I have adopted the extensive classification of Eagleton: (1) reactive and reparative osteitis; (2) nonsuppurative congestive conditions—the symptoms due to venous stasis; (3) chronic bone sepsis (without macroscopic pus); (4) abscess of the apex, (*a*) without a tract and (*b*) with a tract (acute or chronic), and (5) acute septicemic conditions associated with repeated positive blood cultures and meningitis.

Typical Clinical Picture.—The following symptoms, signs and findings may be regarded as typical of suppuration of the petrous apex: (1) neuralgiform pain, especially over the area supplied by the ophthalmic branch of the trigeminal nerve; (2) a discharge from the ear or mastoid wound, (*a*) recurrent or (*b*) continuous; (3) a low-grade sepsis; (4) frequently paralysis of the sixth cranial nerve, and (5) roentgen observations showing destructive changes in the petrous tip.

Clinical Picture.—This, unfortunately, frequently runs an atypical course, and death may ensue without the previous appearance of suspicious symptoms. In 60 per cent of cases only were there symptoms typical of suppurative apicitis. My statistics cover 41 cases observed in 1934.

The onset of the clinical signs of suppurative apicitis usually occurs following a simple mastoid operation performed to drain acute suppurative mastoiditis. Rarely, the symptoms appear in acute suppuration of the middle ear which may or may not be complicated by suppuration of the mastoid.

Pain deep in the eye or around the eye is characteristic when present. The pain is agonizing and nocturnal. There are periods of complete absence of pain. This type of pain was absent in 36 per cent in this series. Low-grade sepsis was present in 70 per cent. In 41 per cent the serious pain and the discharge disappeared and then recurred. In 46 per cent the discharge was constant. Palsy of the sixth nerve, while present in 31 per cent of the cases, cannot be considered as a definite part of the picture. Chills occurred in 1 per cent; labyrinthine symptoms, in 2 per cent; the latter were temporary. Meningeal irritation was noted in 34 per cent of the cases.

Complications.—1. Meningitis was the most frequent and important complication and caused 12 of the 14 deaths in this group. Postmortem examination showed that apicitis is a frequently unrecognized cause of meningitis.

2. Facial paralysis occurred independent of any operative procedure in 1 case. It followed radical operation in 2 cases.

3. Sudden deafness and facial spasms in 1 case were due to involvement of the internal auditory meatus. In another, deafness, labyrinthine irritation and facial palsy followed operation (Ramadier technic).

4. Abscess of the brain developed in 3 cases, located in the temporal lobe in every case. One patient lived. Two died of terminal meningitis.

5. Kopetzky noted bad hearing in 3 cases in which he had done simple mastoidectomy. In 2 other cases, the end-result as to hearing was good. In another case it was normal. In yet another case, after long suppuration, the hearing remained unimpaired.

Mortality.—Thirty-four per cent of the patients in this group died—a mortality much higher than it should normally be. Kopetzky has collected 32 cases of proved apicitis, with 5 deaths, a rate of 16 per cent.

Roentgen Observations.—Roentgen films are of great value in the diagnosis of suppuration of the petrous tip. However, it is not yet possible to determine roentgenologically whether surgical operation is necessary in these cases. An x-ray film should be made early to give one a key film and information as to the structure of the temporal bone. Later films can be made for comparison to determine the progress of the disease. Films should be checked by operative or postmortem findings. Some workers prefer the baseplate; others favor Stenver's position. It seems better to use both positions. Nager states that in early suppuration of the petrous tip there is general cloudiness, later the septums become invisible, and finally the outlines of the tip are wiped out. The infected petrous tip apparently has a greater tendency to heal spontaneously than has the infected adjacent mastoid. Eagleton says this is due to presence of red bone marrow. Infections of the tip can occur rather frequently without symptoms being present. There are changes in the tip in all cases presenting the Gradenigo syndrome. While the x-ray film is an aid, final diagnosis does not rest on it.

THE CLINICAL PICTURE OF CHRONIC INFECTIONS OF THE PETROUS APEX. DR. C. STEWART NASH, Rochester, N. Y.

Chronic infection within the petrous apex presents both a clinical and a pathologic picture of subacute suppuration rather than the proliferating and calcifying process characteristic of chronicity in disease of other types of body tissues.

Clinically, it is an acute process which has quieted down and except for a persistent otorrhea has become symptomless and has remained so sufficiently long to span the usual quiescent period.

When one realizes that an encapsulated suppuration within the apex can produce a definite set of acute symptoms, and that spontaneous rupture of this encapsulation through a large fistulous tract can give permanent symptomatic relief, one has the underlying picture of a chronic petrous infection, and the term of chronicity applies as long as the symptoms are absent and the otorrhea persists.

According to Kopetzky and Almour, coalescent osteitis occurs in fully pneumatized temporal bones; it cannot occur in any other type, that is, the diploic or sclerotic types. If, then, (1) coalescent osteitis occurs only in pneumatized temporal bones, and (2) all chronic otitic infections occur only in nonpneumatized bones (the necrotic otitis excepted), then (3) nonpneumatized bones cannot be the site of chronic suppurative osteitis, and chronic petrous suppuration cannot complicate chronic otitis media.

This pathologic repetition is made to emphasize the fact that chronic suppuration of the petrous apex follows in the wake of acute petrositis and does not complicate chronic suppurative otitis media or chronic mastoiditis.

The clinical picture of chronic petrous infection is as follows: There has been a preceding acute tympanomastoiditis in a well pneumatized mastoid and petrous apex. The mastoid may or may not have been subjected to operation; but at some time, perhaps after a simple or even a radical mastoidectomy, the acute symptoms of involvement of the petrous apex (namely, first division pain, headache, profuse otorrhea particularly through the external auditory canal, fever and a possible paralysis of the external rectus have been present and have disappeared, leaving only a persistent otorrhea which cannot be attributed to any cause except a lesion in the petrous bone. This condition is no longer threatening to life, and study of x-ray films is necessary to establish the clinical diagnosis. In many of these cases the bone heals spontaneously without further surgical intervention

than that already performed, but if symptoms recur, drainage and curettement of the petrous apex usually relieve all symptoms, including the otorrhea.

Conclusions.—1. Chronic petrous infection is clinically an extended quiescent stage of acute petrositis.

2. Adequate drainage through a petrosal fistula explains the disappearance of symptoms.

3. In many of the cases the bone heals spontaneously.

4. A return of symptoms indicates obstruction in the fistulous tract, which usually requires immediate operative intervention.

5. Study of x-ray films is necessary in determining the anatomic structure of the petrosa, in estimating the amount and character of the destruction and in ascertaining whether or not the bony confines of the petrosa are intact.

THE CLINICAL PICTURE OF ACUTE SUPPURATION OF THE PETROUS PYRAMID. DR. C. C. EVES, Philadelphia.

The symptoms and findings in 112 reported cases have been reviewed and classified. A continued occurrence of nocturnal attacks of pain in back of and around the eye, a recurrent or continuous aural discharge, a low grade septic temperature and nervous irritability of the patient constitute the most important diagnostic symptom complex. Transitory facial weakness, nystagmus, nausea and vomiting in the presence of the foregoing symptoms are an important part of the symptomatology. A progressive series of roentgenograms of the petrous pyramid taken during the course of the disease is of value in making a diagnosis. Paralysis of the external rectus muscle occurred in more than 50 per cent of the reported cases. Pneumatic mastoids were more frequently encountered than other types. Two case reports of rather typical symptomatology were given. Some of the reports did not contain important data, and the cases should be classified as "Gradenigo's triad" complicating acute otitis media. In the encapsulated type, the attacks of pain usually progress in severity and duration and are associated with increasing nervous irritability of the patient. The less severe types may heal spontaneously or may resolve into chronic purulent otitis media if sufficient drainage is afforded by a fistulous opening into the middle ear.

FUNDAMENTALS OF THERAPY—SURGICAL AND NONSURGICAL. DR. JOHN R. PAGE, New York.

The discussion has been simplified by the President's suggestion that four questions be answered:

1. Are not the pyramidal cells always involved in acute otitis media and mastoiditis, and does not the condition in the majority of cases resolve after paracentesis or the simple mastoid operation?
2. Does paralysis of the sixth nerve with acute mastoiditis justify radical operation for drainage of the petrous apex?
3. What symptoms after the simple mastoid operation call for more adequate drainage of the pyramidal cells?
4. What are the symptoms that indicate immediate radical operation on the petrous apex, and in what proportion of the cases will serious complications develop if a paracentesis and simple mastoid operation only are performed?

1. Neither the cells in the pyramidal portion nor those in the mastoid portion are involved to a considerable extent in every case of acute purulent otitis media, but when infection has become established in the mastoid cells it will be found to involve to a very considerable extent the cells that surround the semicircular canals and those that lie deeper in the base of the pyramid. The fact that many mastoid wounds heal without the necessity for the removal of the deeper cells should not justify leaving these cells to jeopardize even a small percentage of patients when they can be safely removed.

2. Sixth nerve paralysis alone with mastoiditis does not call for radical operation on the petrous apex. It not infrequently occurs with thrombosis of the jugular bulb and with that of the inferior petrosal sinus in cases without evident involvement at the petrous apex, but when it occurs after a mastoid operation with headache and but moderate fever the wound should be reopened and the deep cells exenterated.

3. Headache with delayed healing or prolonged otorrhea after a mastoid operation with or without paralysis of the sixth nerve calls for reinvestigation of the mastoid and removal of the deep cells in the base of the pyramid. After a radical mastoid operation, examination of the cells below and in front of the promontory on the inner tympanic wall is advisable.

4. Only in exceptional cases is the radical procedure of Eagleton, Kopetzky and Richards indicated or intended to be used. The extensive operation applies to malignant conditions and those in which dead labyrinths are a factor, such as Richards reported. When the labyrinth is active, he prefers the intrapyramidal route and the use of curets instead of the bur to remove the deep cells with the hope of finding a lead to suppuration still deeper in the pyramid. If after the less dangerous exenteration of cells has been performed there is no relief of symptoms, and no lead to deeper infection has been found, further investigation may be necessary. When the labyrinth is active, the approach to the apex may be better from above by elevation of the dura from the surfaces of the pyramid.

When Should a Radical Surgical Operation Be Done? Dr. William V. Mullin, Cleveland.

The answer to this question can be confined to one sentence—"When other measures fail to give relief to outstanding symptoms." Otologists have probably been dealing with infection in this region as long as they have been dealing with infections of the middle ear and mastoid, but, as Eves has said, "Previous to 1929, very few cases were diagnosed before autopsy."

All bone is capable of resisting a certain amount of infection, but red bone marrow, which is related to hematopoiesis and which consists of myeloid tissue, is more resistant than pneumatic bone. The pneumatization of the mastoid is not an indication of the amount of pneumatization of the petrosa or of other portions of the temporal bone. Dr. H. N. Glick of St. Louis, however, demonstrated that in most of his specimens connections exist between the cells of the middle ear, mastoid and petrosal tip, in the region anterior to the cochlea. The whole group of cells may suffer from an infective process and may recover in the same way. Therefore, in a case of otitis media of septic type, an x-ray plate of the cells of the mastoid and pyramid should be made as a "baseplate" for comparison with later plates. Orbital pain, continued fever and aural discharge or reappearance of discharge should arouse suspicion of petrositis. More films of the petrous bone from various angles should be made to determine bone obliteration or changes.

Surgical measures may be, first, conservative (myringotomy, suction or simple mastoidectomy) and then more radical (the radical mastoid operation or the surgical approach to the pyramid).

In my experience, of 7 cases 3 resulted in complete recovery following a thorough cleaning out of all the cells during the acute stage. It required patience and long after-treatment. In 2 cases radical operations were required, and in 2 the patients died.

Fundamentals of Therapy in Petrositis. Dr. Ralph Almour, New York.

I believe that the apparent differences between the various writers on the subject of petrositis are due to the lack of a proper nomenclature. I would urge the use of one based on the anatomic and clinical facts which are evident from the study of cases reported. A proper nomenclature is the key to the fundamentals of

therapy in suppurations of the petrous perilabyrinth. A nomenclature as follows is suggested:

1. Posterosuperior petrositis
2. Postero-inferior petrositis
3. Postero-internal petrositis
4. Anterior supracochlear petrositis
5. Anterior subcochlear petrositis
6. Anterior precochlear (pericarotid) petrositis
7. Apicitis (empyema of the petrous apex)

The determination of whether the lesion is acute, subacute or chronic depends on the clinical findings, and any of the foregoing anatomic designations may be prefaced by the clinical terms "acute," "subacute" or "chronic."

Using this classification, one sees that all lesions of the perilabyrinth cannot be amenable to one type of therapy. Neither can one divide the treatment of petrositis into conservative and radical. What may be conservative for one location is radical for another. To determine the type of petrositis, the minutiae of the clinical picture must be carefully studied. All types are associated with retro-orbital or peri-orbital pain and tympanomastoidal suppuration; the acute and subacute lesions are accompanied, in addition, by a low grade sepsis. Further details to locate the lesion and the treatment then become self-evident.

Posterior Lesions of the Perilabyrinth.—Thorough simple mastoidectomy affords drainage for the milder suppurations. Posterosuperior petrositis shows a fistula above the horizontal semicircular canal and behind the superior semicircular canal which, at times, leads directly to the petrous apex. Treatment is by enlargement of the fistula, with probing and curettage of the tract, followed by saline irrigations and injections of iodized poppy-seed oil 40 per cent. This usually effects a cure, but should symptoms be prolonged, one suspects that the disease has spread from its original site to the apex, and further surgical procedure is necessary.

Postero-inferior lesions show a fistulous tract located below the posterior semicircular canal, which should be handled as described in the foregoing paragraph. Continuation of symptoms calls for further surgical treatment.

Postero-internal lesions are the severest of this group. They extend to the internal auditory meatus and threaten meningitis by rupture at this point. Treatment is by removal of the inner table of the mastoid process, over the lateral sinus, and of the anterior cerebellar surface, careful separation of the dura inward to the internal meatus, and thorough curettage and removal of all diseased structures in the posterior labyrinth, skeletonizing, if necessary, the semicircular canals.

Anterior Lesions of the Perilabyrinth.—These lesions are more dangerous than posterior petrositis because exposure afforded by simple mastoidectomy does not demonstrate them and, on account of this, search for the focus is often delayed beyond the safety point owing to unwillingness of both the patient and the surgeon to expose the tympanic cavity, which is necessary for the discovery of the lesion.

Anterior supracochlear petrositis can be treated by a simple mastoid opening extended to expose the area in front of the superior semicircular canal. The fistula should be treated as described before, or, if extension has occurred, the tract should be converted into a trough extending to the apex. If the symptoms do not subside, thorough exposure of the middle ear is necessary, with intrapetrosal drainage of the apex.

Anterior subcochlear and precochlear petrositis require the opening of the tympanic cavity in order to demonstrate the lesion. Fistulas found are treated as described.

The type of petrositis which one terms "apicitis" or "empyema of the petrous apex" is termed by the Germans *"tiefgelegener Abscess in Felsenbeinspitze,"* and by the French *"ostéite profunde du pointe du rocher."* A special technic is required in this area. All roads in the perilabyrinth lead to this point. Most cases of apicitis fall into the subacute and chronic groups and present a fistulous tract

leading from parts of the perilabyrinth directly to the apex. Proper management of the fistulous tract is needed. In acute apicitis, no tract is demonstrable, and the apex must be attacked directly in order to save the patient's life.

Two methods may be used: the extrapetrosal and the intrapetrosal. The former includes various subdural approaches to the apex, while the latter is limited to drainage of the apex through the temporal bone. Each has indications and advantages. The determination of which method to employ needs careful consideration. Analyzed they are as follows:

Extrapetrosal (Subdural) Routes: The dura of the middle cranial fossa is separated from the superior surface of the petrous bone through (1) the simple mastoidectomy exposure, (2) Eagleton's procedure or (3) the gasserian ganglion approach.

Collectively, these procedures offer: (1) adequate drainage of an extradural abscess which has followed rupture of the superior surface of the petrous bone as a result of apicitis; (2) surgical exposure of the superior petrosal surface and a surgical attack on the apex at its uppermost point. There are the following limitations: 1. These procedures are inadequate in draining the posterior lesions of the perilabyrinth because they do not reach the lesions. 2. They will not reach an extradural abscess which has resulted from a rupture through the apex into the posterior fossa.

Individually, the subdural approaches present the following advantages and disadvantages: 1. The subdural approaches which avoid a radical mastoidectomy and attempt the elevation of the dura through the simple mastoidectomy opening are (except when the abscess is located in the middle cranial fossa) inadequate because (*a*) they do not permit search of the inner tympanic wall for fistulas into the anterior perilabyrinthine space; (*b*) the elevation of the dura must be started behind the superior semicircular canal, and in this way the dural insertions into the subarcuate fossa and into the canal for the petrosal nerves are torn; also, the vascular connections between the dura, the petrous bone and the tegmen tympani are severed, thus increasing the danger of an ensuing purulent meningitis; (*c*) they are technically the most unsatisfactory of all approaches to the apex since the point of attack is farther away from the objective than that of other subdural operations.

Eagleton's technic is rational in that it affords, before anything else is attempted, an inspection of the entire tympanic wall for the presence of fistulas. The dural elevation takes place in front of the subarcuate fossa and emergence of the petrosal nerves; injury to the dura is thus minimal. Squama is removed to allow for cerebral displacement. The disadvantages is that it does not drain apical pus at the most dependent point.

The gasserian ganglion approach does not permit search of the inner tympanic wall for fistulas. It presupposes that the lesion is in the apex, which is not true in all cases.

Intrapetrosal Approaches: The technics followed are (1) Ramadier's and (2) Almour's. These are the operations of choice in acute apicitis because (*a*) they afford a thorough exposure of all avenues of infection to various points of the perilabyrinth; (*b*) they satisfactorily eradicate apicitis except where subdural rupture has occurred; (*c*) the infection and point of drainage are kept within the temporal bone and away from the endocranium, thus lessening the chance of meningitis; (*d*) they afford drainage at the most dependent point of the apex.

Conclusions.—No one operative procedure suffices for all cases of petrositis.

For the majority of cases of petrosal suppuration there is no need of mastery of special technic. Most cases show a fistula in the perilabyrinth which, in most cases, leads directly to the tip; or they show necrosis at the internal auditory meatus, just anterior to Trautmann's triangle.

Treatment consists of deft use of a curet, widening of the fistula with a bur, washing with saline solution to evacuate pus and curettage of granulations within the perilabyrinthine cavity.

If disease within the perilabyrinth is not exposed by simple mastoidectomy, a radical mastoidectomy must be done in order to demonstrate the anterior part of the perilabyrinth.

In an encapsulated empyema of the apex, a specialized technic is required. Whether a subdural or an intrapetrosal approach is used, the operator must be thoroughly familiar with the anatomy of the operative field, aware of the advantages and the disadvantages of the various technics, and convinced that the patient has an encapsulated empyema of the apex.

SURGICAL ANATOMY OF THE PETROUS APEX. DR. WELLS P. EAGLETON, Newark, N. J.

The petrous apex is primordially a cranial adaptation of a red bone marrow-filled epiphysis with "working" sinusoidal spaces and of the growing proliferating end of a metaphysis. Thus, because of its embryologic origin and specific morphologic structure, it may be the seat of those familiar types of osteomyelitic infection which attack the ends of a long bone or the substance of irregular bones. However, its position in the head brings any infection of its sinusoidal marrow spaces into direct communication with the numerous vascular channels for venous discharge, as well as into intimate relationship with the incoming arterial supply of the endocranium, of the dura and of the soft meninges, by any of which pathways the apical suppuration may reach the cerebral circulation and thus the cerebral tissue itself.

Vascular Paths of Infection from the Apex.—The sinusoidal marrow spaces within the bone of the petrous apex empty into (*a*) the superior and inferior petrosal sinuses and (*b*) the small venous plexuses connecting the cavernous sinus with the tympanomastoid area, while (*c*) the carotid artery and its surrounding carotid plexus pass through the apex.

The younger the bone the freer and more intimate are these vascular connections; most of the smaller plexuses become obliterated by the completion of osseous growth. Thus, infection of the sinusoidal marrow spaces of an apex may be transmitted by perivascular or vascular pathways not only extradurally but also into the subdural or intracerebral tissues. Consequently, intra-arachnoid infections occur frequently while the bone is growing; for there is macroscopic evidence that the condition of the petrous apex is the exciting cause in many cases of meningitis occurring during infancy which are classified as of unknown origin.

Early Appearance of Neighborhood Symptoms of Infections of the Apex.—Invasion of the apex is usually first manifested by nervous and stomachal symptoms, the associated blood vessel and neurologic lesions being present long before there are macroscopic changes in the bone itself; for bony changes, both morphologic and radiographic, occur much later.

Sinusoidal Osteomyelitis of the Apex.—As long as the infection is within sinusoidal spaces of the marrow no gross changes are to be seen macroscopically. At operation or autopsy, the osseous structure appears normally firm, the only change observable being in the red bone marrow, which may appear rather too red or slightly juicy.

Later, the infection is manifest by diffuse miliary abscesses in the marrow, which are accompanied by changes in or destruction of the bone trabeculae. Diffuse foci of infection now coalesce, causing an encapsulated abscess which may fill the medulla of the apex, leaving the compact bone of the cortex still intact, or perforate either the superior surface or the posterior surface, or both.

Extradural Abscess and Phlebitis.—When the perivascular infection is extradural it is manifest (*a*) by the well known extradural abscess over the apex or (*b*) by a petrosal or cavernous sinus thrombosis. When, however, the infection, which is really a sinusoidal osteomyelitis of the apex, passes out of the bone marrow (as it is primarily a blood space infection) it attacks the coats of the adjacent blood vessels and thus may cause (*c*) thrombophlebitis of the carotid.

Localized Intradural Lesions from Infection of the Apex.—If the vascular infection passes the dural envelop and enters the meninges, it causes an obliterating phlebitis or an arteritis. When this ruptures because of lack of adventitia in the intradural vessels, it gives rise to either (*a*) a local abscess or (*b*) general formation of pus in the subarachnoid spaces—suppurative meningitis—or (*c*) an abscess of the subdural space, the center of the infection being a ruptured thrombosed vessel.

Erbleichung.—Entrance of the infection by vasculitis into the cerebral tissues is evident by a local *Erbleichung* (Spielmeyer) of, and punctate hemorrhages into, the deep cerebral tissues, associated with cerebral edema, the former being so slight that it is generally overlooked.

Distinctiveness of Lesions from Infection of the Apex.—The lesions may be (*a*) a pyogenic sinusoidal condition; (*b*) osteitis, commonly seen in mastoiditis; (*c*) plasma cell mastoiditis. In all cases, an infective lesion of the apex is pathognomonic, and runs a distinctive course because of the inherent red bone marrow-producing properties of the bone. Consequently, the petro-apicitis calls for a different surgical point of view from that of infections of adjacent osseous tissues, such as mastoiditis, nasal sinusitis or osteomyelitis of the cranial vault, with each of which suppuration of the apex is a frequent but not an invariable complication; for it may be the primary lesion of the bone.

Type of Infection of the Mastoid During Growth.—A true osteomyelitic mastoiditis is common in infants and in children before the third year, but is limited to small areas of remaining marrow, which may be adjacent to the mastoid in an adult. After the third year there is no tract of fat marrow within the domain of the mastoid apophysis. Consequently, while the mastoiditis of infancy is generally a true osteomyelitis, partaking of the nature of an endothelial infective process, primary osteomyelitis is infrequent in the domain of the mastoid apophysis after the second year.

Diffuseness of Osteomyelitic Processes.—In infants and children, when acute phlegmonous osteomyelitis originates from a suppurative otitis, it is apt to involve the entire temporal bone, only the labyrinth escaping; a low grade infection is frequently limited to the squama and antromastoid areas.

However, this macroscopic osteomyelitis of the petrous apex never extends to the sphenoidal basis in childhood, although after maturity an acute "juicy" infection of the bone marrow of the sphenoidal basis is not an infrequent accompaniment of acute phlegmonous osteomyelitis of the apex.

SUMMATION AND CONCLUSIONS OF SYMPOSIUM ON SUPPURATION OF THE PETROUS PYRAMID. DR. HAROLD I. LILLIE, Rochester, Minn.

The syndrome of suppuration of the petrous pyramid may be considered to be an established entity. One needs to be familiar with many facts regarding this disease. From the anatomic standpoint, it is known that the conformation and structure of the petrous pyramid are so variable that it is difficult to describe the normal. The structure may consist of cancellous bone with the spaces almost entirely occupied with red bone marrow or with an almost purely fatty marrow or with a mixture of these two types of marrow. It also may consist of solid, dense bone with only a small amount of fibrous tissue, or it may have a high degree of pneumatic cellular development.

The surgical relations are very important, and the effect that the disease of the petrous pyramid may have on certain intracranial nerves may be of great importance from the standpoint of the diagnosis of the situation of the lesion.

The symptom complex characteristic of suppuration of the petrous pyramid is pain in, around and above the eye, a discharge from the ear and a general picture of low grade sepsis. A palsy of the sixth nerve may be present. The pathologic changes that take place in the petrous pyramid are fairly well understood. They may be an osteomyelitis, an osteitis or a closed empyema. The treatment of the disease is essentially surgical, and if one could locate the lesion accurately by the

correct interpretation of symptoms and signs, one could proceed directly to the pathologic process. In the present state of knowledge, it is not probable that this accurate localization can be accomplished in many cases.

The surgical approach should be conducted in an orderly manner. Exploration of the cells around the labyrinth and toward the zygoma should be made, and if the disease is not located, one can then extend the search by proceeding to perform a radical exposure of the field and direct his attention to the peritubal and carotid cells. There is no one surgical approach that will adequately meet the surgical requirements. The optimal time for surgical intervention may be difficult to determine. Each patient will always be a problem for individualized surgical judgment.

DISCUSSION

Dr. Samuel Kopetzky, New York: In this discussion, emphasis has not been placed on the clinical picture. According to Ramadier, one has to deal with two forms of osteomyelitic lesions in the petrosal pyramid. One form is termed hematogenic. This type fits in with the form which Dr. Eagleton describes as characterizing his acute septicemic cases. The second form is otogenic. The first type is usually found in the very young. The clinical picture is one of generalized infection. The symptoms are marked prostration, gastro-enteritic disturbance and often signs of pulmonary involvement, which cloak the advance of the infection as it infiltrates the diploic bone with its contained marrow in the petrous pyramid. Otitic phenomena are present but not predominant. Finally, the lesion reaches the endocranial structures, and the terminal picture is one of meningitis. One significant point is that the lesion is usually bilateral.

Otogenic osteomyelitis, on the other hand, follows the type of otitic infection. It occurs in the course of middle ear infection, often when the acute stage has become subacute. Its onset, however, is marked by acute signs. There are marked pain, discharge and rise of temperature. The periauricular region is more painful than the mastoid process. Edema spreads to the surrounding regions. Metastatic foci may appear in the lungs or anywhere in the body. If the disease is not checked, death may ensue from sepsis, pulmonary complications or meningitis. With this clinical picture, a positive roentgenogram discloses a spread of the lesion in the squama or in the adjacent bone tissue of the parietal or occipital bone. Decalcified bone is shown in the petrosa and often in the zygomatic areas.

With reference to the therapeutic indications, one must recognize: (*a*) the otomastoidal stage, (*b*) the intrapetrosal stage and (*c*) the peripetrosal stage.

The readers of papers today have stressed the study of clinical and anatomic minutiae, which will enable one to select the proper therapeutic approach, and this will, after a period of competent supervision, be surgical.

Dr. Harold G. Tobey, Boston: My experience has been that suppuration of the petrosa may occur at any level between the base and the tip and give rise to the identical symptoms which have been enumerated today. This may account for the differences of opinion as to management of any given case. Let us consider a few of the essential points: 1. It is agreed that such cases occur in the pneumatic type of mastoid. 2. The four periods of progressive involvement are distinct: (*a*) the pain has been been described as "behind, in or around the eye." Many patients are unable to localize pain. Less typical pain may also mean dural irritation near the base of the tip. (*b*) An aural discharge is almost a sine qua non, but I had a patient, a girl of 15, in whom there were all the typical symptoms except the aural discharge. Operation was withheld until the onset of meningeal signs. Fortunately, the outcome was successful. (*c*) The period of low grade sepsis seems to be constant. (*d*) I have not observed the period of quiescence mentioned by some workers.

The value of the x-ray film is none too conclusive. The roentgen findings should be taken in conjunction with clinical signs. If in doubt, one should use a basal, an anteroposterior and a Stenvers position. Sometimes complete destruction of the tip, with regeneration of bone, may occur, as shown by the x-ray film, without the necessity for operative intervention.

Dr. Isidore Friesner, New York: Correlation of anatomic and histopathologic studies with clinical experience makes evident certain facts which are of fundamental importance in the therapy of suppurations of the petrous pyramid. Among these are:

1. The suppurating petrous pyramid tends to drain and heal spontaneously.

2. By no means does the lesion in the petrous pyramid in every case extend to the apex. Nor are the symptoms dependent on extension of the lesion to the apex.

3. The posterosuperior route is the frequent pathway of extension, and the greatest expression of the disease process is noted in the area between the superior semicircular canal and the internal auditory meatus, at the posterior superior margin of the petrosa.

4. In my clinical experience, the cessation of pain, in all but one instance, marked beginning of recovery.

5. With the foregoing facts in mind, certain indications have been established.

6. It is obvious that no one procedure is adequate to drain all foci in the pyramid.

Dr. George M. Coates, Philadelphia: Petrositis is not a new subject; the disease has been recognized for years. The fact that the petrous bone is pneumatized and that the spaces may be the seat of suppuration does not mean that a radical surgical operation is always necessary. Before much was known about the surgery of the petrous bone, many of these conditions cleared up without surgical intervention. I believe my associates and I have operated in these cases at an earlier date than that which Dr. Eagleton states. This discussion has cleared up some confusion as to the distinction between empyema of the pneumatic cells of the petrous bone and osteomyelitis. Some confusion is caused by the fact that petrosae contain all types of bone; in some the bone is pneumatic; in some, diploic; in some, mixed; there are probably more with mixed types of bone. Most petrous pyramids have some cells in them. Conservatism in treatment may be necessary, but that does not mean one should adopt a static attitude. In some cases, radical surgical treatment may be the real conservatism. In all, however, I believe there has been over emphasis on radical surgical intervention. One is afraid of the results should the case fall into the hands of a tyro. On the other hand, patients have died for lack of operative intervention. X-ray films may be misleading. Key plates should be taken early to be used for comparison with subsequent exposures. Then one has definite information as to whether one is dealing with the pneumatized type, the diploic type or mixed types of bone. There are also other cases in which trigeminal pain is present, and these must be ruled out in order to make the correct diagnosis.

Dr. Harris H. Vail, Cincinnati: I wish to bring up the importance of the great superficial petrosal nerve. In 1932 I stated that the ocular pains typical of petrous suppuration were not due to irritation of the ophthalmic division of the fifth nerve but were the result of irritation of the great superficial petrosal nerve. Sufficient study has not been made of this nerve in any of the sections, but it should not be difficult in a fatal case of suppuration of the petrous apex to show the relations of the great superficial petrosal nerve, and study of this would answer an important question. This nerve carries sensory fibers from the sphenopalatine ganglion to the geniculate ganglion. I have had the idea of cutting this nerve to relieve pain due to chronic sphenoiditis. The emergence of the nerve on the petrous bone shows such variation that at times it would require deep exposure to reach the nerve; also, it is so firmly bound to the dura that it can be torn by elevation of the latter.

Orbital and ocular pain is not present in all cases of petrositis. This fact can be easily explained by a consideration of the route of extension of the infection to the petrous apex. If the infection points toward the posterior surface of the petrous bone there is of course no relationship with the great superficial petrosal nerve and there will be no ocular pain. However, in such cases the abducens nerve

in Dorello's canal is menaced. Therefore, I should say that the presence or absence of referred pain in the eyeball or orbit is a very valuable aid in indicating the particular surgical approach.

Dr. Francis L. Lederer, Chicago: The involvement of the petrous apex is associated with a definite symptom complex. It is believed that a definite pathologic entity has been established. Recent contributions are in the main based on anatomic investigations which tend to elucidate the pathogenesis and therapy of this disease, apparently known to clinicians for the past seventy-three years. The literature, however, presents some confusion as to therapy; all types of treatment are advised, ranging from conservatism, expectant management, roentgen treatment of the mastoid, thorough simple mastoidectomy to, on the other hand, thorough radical surgical attack. This confusion arises undoubtedly from the fact that two distinct pathologic entities are being considered. In my experience, petrositis, as defined by Kopetzky, is not identical with the classic Gradenigo syndrome. Confusion between these two conditions alone has led to the association of conservatism in the conduct of a case complicated by an abducens paralysis with conservatism in the management of suppuration of petrosal pneumatic cells (in which abducens involvement is of rare occurrence).

I believe in order to clarify one's position one should use terms not only correct anatomically and pathologically but applicable clinically. The term "pneumatic petrositis" should be applied to the type characterized clinically by deep orbital pain and continued otorrhea. In the stage in which there is hyperemia of the petrosal pneumatic cells the condition is amenable to conservative treatment. In the later, osteitic stage the process is approachable by the middle ear, an exploration being made between the cochlea, the tubal orifice, the carotid canal and the tegmen petrosi. The subacute and chronic types present the less formidable problem.

The other type of disease I should call "diploic petrositis." It is unapproachable except by taking down the buttresses as provided by the Eagleton technic.

Dr. Fletcher D. Woodward, University, Va.: My experience and that of my associates in the study and treatment of petrositis have covered the following points:

1. Pain, when distributed over the first division of the fifth nerve, has been typical and has been the most suggestive early symptom. This is distinct from pain associated with pathologic conditions found in the nose, sinuses, nasopharynx, pharynx and teeth, often coexistent in these cases.

2. Otorrhea, persistent, recurrent or suddenly increased, is also characteristic.

3. Abducens paralysis is found in so many conditions that it is not considered significant.

4. Roentgenography, in our hands, has been disappointing. I believe, however, that this is a question of experience and technic. We now make routine x-ray pictures of the petrous tip in all cases of mastoiditis.

5. Primary suspected petrositis is an indication for mastoid operation, especially in the presence of marked pneumatization. If evidence of dural irritation is found at operation, by necrosis of the plate or an epidural abscess, we are content to wait, as we find that dural irritation can produce the pain of petrositis. If pus is liberated from the cells deep within the mastoid and adjacent to the petrous pyramid, we are again content to wait and watch progress.

6. The patient who has had an operation and who presents symptoms of petrositis is more apt to have true involvement. In several instances, however, the finding of dural irritation, sequestrums or unopened cells has been sufficient to account for the symptoms.

7. When none of the aforenamed conditions explains the symptoms, one is facing a more serious problem. In a few cases the petrous apex drains spontaneously through the middle ear and eventually heals, but one has no assurance of this. One must evolve a proper surgical technic.

Our procedure is as follows: First, we search carefully for a fistula either from the mastoid or the tympanum. When it has been found, we watch the

progress to see if sufficient drainage has been established. When no fistula has been found and the condition of the middle ear does not warrant radical operation, we have a problem as yet unsolved by us.

Second, when we are unable to discover a fistula, either from the mastoid in simple operations, or from the tympanum in radical operations, or when we are faced with the problem of doing a radical operation though the condition of the middle ear does not justify it, we decide what type of surgical approach we shall follow: the tympanic approach of Kopetzky and Almour or one of the extradural approaches advocated by Eagleton and others. My inclinations have been toward the extradural approach of Myerson or the old gasserian ganglion route.

Finally, when rupture has taken place and meningitis is either present or imminent, I believe an extradural approach offers a better prognosis, and that the technic of this approach should be developed and improved.

Wednesday Morning Session, May 29

REPORT OF COMMITTEE ON OTOSCLEROSIS: FINANCIAL REPORT. DR. ARTHUR B. DUEL, New York.

The permanent fund for research, like all other such funds, suffered from the financial depression but has now crystallized into a book value of $300,000 with, we hope, a stabilized income of about $15,000. We could use with advantage $10,000 more.

This year we allocated subsidies from our income and a special contribution—$14,500 in all.

We should not have undertaken more had our fund been larger, but we should have liked to be more generous in the amounts allocated to each.

The manuscript for the third volume, a résumé of the literature on otosclerosis up to date, is nearly completed. We expect to publish this early in 1936. Dr. Wilson will speak on the work accomplished under the various subsidies. We are fortunate in having on our staff the kind of men who turn out the highest quality of work regardless of the stipend.

REPORT OF COMMITTEE ON OTOSCLEROSIS: SCIENTIFIC REPORT. DR. J. GORDON WILSON, Chicago.

Investigations during the past year have been diverse and may sometimes appear to have little relation to our problem of "Progressive Deafness." But we are hopeful that the time approaches when some light will be thrown on this problem. Some of the chief points of the work submitted to the Research Committee are as follows:

Dr. Bast is continuing his study of the periotic bone in the child and of the efficiency of the utricular valve. Also, in collaboration with the professor of physiology at the University of Wisconsin, he is carrying out experiments on the Wever and Bray phenomenon. The physiologic results are being checked by an anatomic study of the tissues involved. Dr. Bast's knowledge of histology is of great value here.

Dr. Culler has continued his investigation almost entirely with conditioned animals. Checking his previous findings on the membrane in the round window, he finds that an increase in electric pick-up from this area can be had by using any good conductor, such as saline pledgets, and that this increase is a question of increased transmission and is of no direct acoustic significance. He repeated his work on roentgen irradiation of the whole auditory tract to show the effect on auditory acuity and found that acuity was increased but that the increase was of brief duration. He worked out the acoustic values of the auditory tract and found that little loss of hearing comes from the loss of one cerebral cortex, but great loss from complete decortication. The completely decorticated dog is still living

and is said to be one of the best decorticated animals reported on in the literature. He reports on the effect of cerebrospinal pressure on hearing, and believes the variations to be due to impaired function of the round window.

Regarding the effect of protracted exposure to loud tone, in conditioned animals Dr. Culler found: Exposure to a tone of 1,000 decibels, the intensity of which was 110 to 115 decibels above the animal's threshold, caused a fall of hearing throughout the entire range from 200 to 5,000 cycles. The drop at each frequency is about the same, from 70 to 80 decibels. Exposure at 3,000 cycles has similar consequences, but with some indication of differential effect, the lower frequencies (from 500 to 1,000) are less affected than the others. The effect of intense stimulation on the electric phenomena of the cochlea is obscure. The electric response in a dog whose hearing had dropped 70 decibels was of almost normal magnitude. In cats, after ten hours' exposure to intense tone, there seems to be little, if any, reduction; the electric pick-up remains the same throughout.

Dr. Anson has studied the complicated folds of the endolymphatic duct by means of which it is believed endolymph resorption takes place. He continues his histologic investigations of the area between the cochlea and the stapes, the seat of predilection for otosclerosis. He has reconstructed models in wax which clearly show, in three dimensions, the formation and histologic variations of tissues in this area. Study of these tissues indicates that they are unstable; the constituent cells can progress in a variety of ways, and not alone to the type normal to this area; the progression may be arrested at various stages and intermittently resumed, resulting in structures of different histologic type.

Dr. Fowler Jr. has been assiduous in collecting and preparing sections of temporal bones. He has studied 3 cases of acoustic tumors. Such cases, since Gray's paper on otosclerosis, have assumed a new significance. He has made interesting observations on osteoid tissue. Dr. Fowler Sr. has continued his study on the effect of quinine.

Dr. Marvin Jones, with Dr. Hemsath, is continuing the study of infections of the temporal bone, correlated with general disease, with special relation to the petrous tip. He has collected and used considerable material. Dr. Hemsath is studying neonatal otitis and otitis in the new-born. He has described the reaction of the middle ear of the fetus to foreign bodies, also complications of ear infections in the fetus and infant.

Under Professor Tait at McGill University, work with conditioned animals is being carried on related to the following problems: (1) the localization of pitch in the cochlea; (2) the effect of interruption of the chain of ossicles on hearing; (3) tremor receptors in cats deprived of the cochlea; (4) the effect of bilateral sympathectomy and its influence on the blood supply of the petrous bone.

Report from Dr. Davis and his colleagues at Harvard University states that by electric methods they have obtained audiograms of the hearing of normal cats and guinea-pigs. With these as a basis, they have studied the hearing in diseased ears of laboratory animals. They have shown that masking is associated with the nerve impulse and not with the cochlear response, and that it is peripheral. They have found that noise travels by the same nerve fibers as pure tones. Bringing the acoustic nerve in line with other nerves, they found that the conduction rate in the auditory nerve is the same as that in the nerve fibers of similar diameter elsewhere in the body, and that intensity of tone is represented by the number of fibers activated, and not by the number of impulses transmitted per second.

Dr. Nielson, president of Smith College, reports on the activities of the Clarke School for the Deaf. He has drawn attention to the work of Dr. Heider, who pointed out the abrupt rise in number of children registered in schools for the deaf who were infants during the influenza epidemic of 1918. While the number born in other half years does not exceed 267 and averages 200, there are 536 children who were born in the second half of 1918. The question whether this rise is due to the drugs given, notably quinine, should be made the subject of research.

REPORT OF THE NEW YORK COMMITTEE ON OTITIC MENINGITIS. DR. JAMES G. DWYER, New York.

The work of the Committee on Meningitis was suggested by Dr. George L. Tobey in his presidential address in 1933. Late last fall we started to work out this scheme in New York. Since December we have seen 28 patients with otitic meningitis, and I know of 40 others, seen in consultation, since that time. Realizing the urgency of the situation, we appointed a key man in every large hospital and agreed that each patient with this disease should be seen by the committee to check up on findings independently of the hospital. Our questionnaire covers the following points:

1. One by whom the report is made
2. Institution in which the patient is treated
3. Previous history as regards diseases of the ear, nose and throat
   (*a*) Otitic infection
   (*b*) Paranasal sinus infection
4. Clinical history of earache
   (*a*) Was there paracentesis?
   (*b*) Was there abscess?
5. History of headache, nystagmus, opisthotonus, diplopia, Kernig's sign, Babinski's sign, etc.?
6. Ophthalmologic findings
7. Examination of the blood
8. Findings in the spinal fluid
9. Procedure as to treatment, medical and surgical
10. Consultations and opinions
11. Outcome of case
12. Filing of specimen for autopsy
13. Opinion of men who saw the case
14. Final remarks by the committee

Definition of Meningitis.—The literature does not state what is meningitis and what is not. This has an important bearing on the treatment. One writer may report cures in 75 per cent of cases; another states he has 100 per cent mortality. This discrepancy is due to two factors: (*a*) ignorance of what constitutes acute purulent suppurative meningitis and (*b*) ignorance of bacteriologic work.

With reference to (*a*), our committee defines meningitis as that condition in which the organism is demonstrated in smear or culture or both. If the organism is not found in the spinal fluid, we do not consider that case as one of generalized meningitis, even if the fluid is cloudy and has thousands of cells. Demonstration of the organism is a *conditio sine qua non.*

The bacteriology of the spinal fluid (*b*) is very important. The literature contains contradictory statements, such as: "The organism can be demonstrated in the smear but cannot be cultured." Or, "The organism is gram-positive and gram-negative in the same specimen." Biologically, the organism is what is known as gram-positive. The epidemic variety of meningitis is due to a gram-negative organism. The organism from otitic or rhinitic meningitis is gram-positive. However, the organism loses its staining reactions if it is dead or dying, or if it has been acted on by the bactericidal properties of normal spinal fluid. Hence, in ignorance of this fact, workers have called the same organism gram-positive and gram-negative. The organism also may have suffered injury and may not be able to be grown on culture.

The cloudy spinal fluid in cases in which no organism can be demonstrated is due to tissue reaction; that is, it represents nature's protest against invasion and irritation of the meninges.

Importance of the Blood Count.—The surest guide to the presence of meningitis is the blood count. With a white cell count of 40,000 in an adult, including 35 per cent or more polymorphonuclears, there is likely to be either pneumonia or meningitis. This may be present only a few days, during which time the patient complains of intense headache; there may still be normal temperature, but if the blood count shows 88 per cent polymorphonuclears, and the chest is still clear, watch that case.

Another important point is the pathway of infection. We have had to alter our conception as to how the mastoiditis occurs. At first we thought it tubal, but autopsy studies have convinced us that it is not a primary invasion from the tube. It comes in from the sphenoid; in such a case the patient is foredoomed. Even if a clean mastoid operation is done and the patient appears to be progressing, he suddenly presents a fulminating meningitis. I believe this is an osteomyelitic process. The mastoid condition is merely an incident.

Type of Organism.—In 5 cases there were hemolytic streptococci. In 20 there were pneumococci. The patients all died. There was 1 case of infection with Bacillus coli, in which the patient also died. Two of the 26 patients got well. Pneumococcus of type III causes mastoiditis to develop into meningitis. The patient with this condition suffers intense headache. The blood count must be carefully watched. In a case of this kind a man had labyrinthine disturbance; there was no fever.

Methods of Treatment.—The Kubie method, in our hands, has not proved satisfactory. In 1 case it hastened the end by causing general anasarca. It is necessary to have a free flow from the brain down. If the flow is dammed, edema of the brain develops. If there is a free flow one does not need the Kubie method. There will not be a satisfactory method of cure until there is a potent antimeningococcic serum. The cases in which recovery occurs must be the ones in which the organism in the patient has its counterpart in the serum being used. In the cases in which recovery takes place spontaneously the factors are the type of organism, the grade of virulence and the phagocytic qualities of the spinal fluid.

DISCUSSION

Dr. Joseph C. Beck, Chicago: In all my experience, I have known of only 2 cases of meningitis of the type described by Dr. Dwyer in which recovery followed operation. Our organization has been carrying on this work ever since being invited to do so by the committee from New York. I selected 5 men of the type who would understand what was required of them. We have a number of cases studied. Two points that Dr. Dwyer brought out should be recognized: (1) the blood count and (2) the Kubie treatment. We have found a wet brain in every case in which this treatment has been used. We have found a careful study of the blood count to be the most essential diagnostic aid.

A Further Contribution on the Auditory Function and Labyrinthine Reactions of One Hundred Children in the Clarke School for the Deaf. Dr. Gordon Berry, Worcester, Mass.

A careful review of the acoustic capacity of 100 unselected children at the Clarke School for the Deaf is reported. Graphs made with the aid of a specially designed and amplified 2-A audiometer show that these so-called deaf children have varying amounts of residual hearing. After a consideration of the causative factors of the deafness of these children their graphs are classified according to the type of the curve and according to the amount or degree of hearing loss.

An accompanying study was made of their vestibular reactions. Since authors differ as to the reaction time of a normal vestibular response, a control group of 58 normal children was tested. The average reaction time for the control group was 12.6 seconds, with a range of from 9 to 34 seconds; while the average for the 100 deaf children was 9.85 seconds, with a range of from 0 to 26 seconds. It was difficult to find any correlation between the amount of postrotatory nystagmus and

the type of deafness in a given case. Also there was a considerable and unexplained variability in the duration and in the intensity of the reactions. Taking the group as a whole, however, the postrotatory nystagmus diminished as the deafness increased.

It is hoped that an analysis of these charts will give otologists a clearer conception of the types of deafness encountered in the more serious juvenile cases and will permit educators of the deaf to apply more intelligently the different procedures and helps available.

ONE HUNDED UNSELECTED PUPILS AT THE CLARKE SCHOOL FOR THE DEAF. DR. RUTH P. GUILDER and LOUISE A. HOPKINS, Worcester, Mass.

As the result of an analysis of the acoustic capacity of 100 unselected pupils at the Clarke School for the Deaf a classification has been evolved for use in schools for the deaf, based on four classes, designated by Roman numerals, according to type of graph, and on three subdivisions, designated by the letters A, B and C, according to level of graph. The chief characteristics of the four classes are briefly as follows: Class I graphs tend to be horizontal. Class II graphs are composed of two or three segments, the direction being descending in the first half and horizontal in the second half of the graph. Class III graphs are composed of several segments, the direction being mainly descending, with a sharp rise at the end. Class IV graphs tend to descend from left to right in a more or less straight line. The A, B and C subdivisions have been made on a definite mathematical basis so that, from the standpoint of amount of residual hearing, subdivisions A constitute a hard of hearing group, subdivisions B, a partially deaf group and subdivisions C a profoundly deaf group.

Of the unselected group of 100 pupils, 46 per cent fall in classes I, II and III. Pupils in these classes have a wider frequency range than those in class IV, many responding to some or all of the speech-sound frequencies (the range from 400 to 8,000 double vibrations), while the majority in class IV cease to respond at 1,024 double vibrations, having little residual hearing over most of the speech-sound range. From the standpoint of level of graph, 45 per cent fall in the A and B subdivisions and constitute a hard of hearing and partially deaf group. This means that the education of a large proportion of deaf children should proceed more and more nearly along normal lines, but to bring these progressive changes in the education of the auditorially handicapped a classification along the lines of the A, B and C subdivisions seems essential.

Analysis of acoustic capacity by air and bone conduction according to class and subdivision shows (1) that the hearing loss tends to increase for the higher tones by both air and bone conduction as one passes from class I to class IV, but that the number of failures of response at maximum intensity for the higher pitches increases more rapidly by bone conduction than by air conduction, and (2) that the deviation of the air conduction threshold from normal is increasingly greater than that of the bone conduction threshold from normal as one passes from the A to the C subdivisions in each class.

The most striking point in the etiologic composition of the classes and subdivisions is the fact that 44 per cent of the congenital and probably congenital groups are distributed through classes I, II and III, and that 44 per cent of the congenital and probably congenital groups belong to the A and B subdivisions, that is, to the hard of hearing and partially deaf subdivisions. This means that congenital deafness does not necessarily imply a typical descending curve or profound or total deafness, according to some of the earlier conceptions.

A study of vestibular function in the same group of deaf children revealed that the mean duration of horizontal postrotatory nystagmus for the entire deaf group was 9.95 seconds, and for a normal group of the same age range, 19.6 seconds. There appears to be no definite correlation for individual patients between type or level of graph and duration of postrotatory nystagmus, since there are persons

in classes I and II and in subdivisions A giving no reaction, and persons in class IV and in subdivisions C giving reactions well within normal limits. However, in a group of 100 deaf children there appears to be a steady increasing deviation from the normal mean as one passes from subdivisions A to subdivisions C.

EVALUATION OF CALORIC TESTS IN LOCALIZATION OF LESIONS OF THE POSTERIOR FOSSA: A STUDY OF FORTY VERIFIED CASES. DR. JACOB L. MAYBAUM and DR. MORRIS GROSSMAN, New York.

This article will be published in full in a subsequent issue of the ARCHIVES.

Book Reviews

Methoden zur Erforschung des Kochlearapparates. Edited by Professor Emil Abderhalden. **Handbuch der biologischen Arbeitsmethoden.** By Fritz Kleinknecht, Leipzig. Price, 7.20 marks. Pp. 130, with 83 illustrations. Berlin: Urban & Schwarzenberg, 1935.

This section of the extensive work on methods of biologic study gives in detail all manner of operative procedures on the hearing apparatus of animals. The technic is presented clearly, and the illustrations add much to the understanding of the methods employed. It is to the credit of Kleinknecht that, contrary to what one finds in many of the German works, he is familiar with the English and American literature and quotes freely the publications of the research men in the English-speaking countries. As instances, the articles of Houston and Crowe are quoted, as are those of Wever and Bray. In latter years so much interest has been shown and so much work has been done on the investigation of the hearing function in animals that perusal of this small volume should prove of great value to students of this subject. Here they will find details and illustrations which will guide them in their problems.

Ear Exostoses. By Aleš Hrdlička, Curator, Division of Physical Anthropology, the Smithsonian Institution, Washington, D. C. Smithsonian Miscellaneous Collections, vol. 93, no. 6, 1935. Pp. 100, with 5 plates.

Hrdlička has compiled a brochure of one hundred pages, including a bibliography covering the entire subject. There are five plates of ten photographs of exostoses of the external canal in dry bone preparations. The author undertakes to cover the entire knowledge of exostoses in man, including historical remains. The study includes an exhaustive review of the literature.

News and Comment

CASSELBERRY PRIZE FUND

The sum of $500 has now accrued from the Casselberry Fund for encouraging advancement in the art and science of laryngology and rhinology and is available, in part or as a whole, for a prize award, decoration or the expense for original investigation or research in the domains mentioned. Theses or reports of work must be in the hands of the secretary, Dr. James A. Babbitt, 1912 Spruce Street, Philadelphia, before February 1 of any given year.

Directory of Otolaryngologic Societies *

FOREIGN

Collegium Oto-Rhino-Laryngologicum Amicitiæ Sacrum

President: Prof. Gunnar Holmgren, Karolinska Mediko Kirurgiska Institut, Stockholm, Sweden.
Secretary: Prof. Dr. C. E. Benjamins, Verlengde Heereweg, 143 Groningen, The Netherlands.

NATIONAL

American Medical Association, Scientific Assembly, Section on Laryngology, Otology and Rhinology

Chairman: Dr. Ralph A. Fenton, 1020 S. W. Taylor St., Portland, Ore
Secretary: Dr. Gordon B. New, Mayo Clinic, Rochester, Minn.
Place: Kansas City, Mo. Time: May 11-15, 1936.

American Academy of Ophthalmology and Otolaryngology

President: Dr. Wells P. Eagleton, 15 Lombardy St., Newark, N. J.
President-Elect: Dr. Frank E. Burch, 408 Peter St., St. Paul.
Executive Secretary: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.

American Bronchoscopic Society

President: Dr. H. M. Taylor, 111 W. Adams St, Jacksonville, Florida.
Secretary: Dr. Lyman Richards, 319 Longwood Ave., Boston.

American Laryngological Association

President: Dr. Dunbar Roy, 113 N. Pryor St., Atlanta, Ga.
Secretary: Dr. W. V. Mullin, 9204 Euclid Ave., Cleveland.

American Laryngological, Rhinological and Otological Society, Inc.

President: Dr. Thomas E. Carmody, 227, 16th St., Denver.
Secretary: Dr. R. L. Loughran, Sharon, Conn.

SECTIONS:

Eastern.—Chairman: Dr. Frederick T. Hill, Professional Bldg., Waterville, Maine.
Southern.—Chairman: Dr. Beverly R. Kennon, Medical Arts Bldg., Norfolk, Va.
Middle.—Chairman: Dr. Daniel W. Layman, Medical Arts Bldg., Indianapolis.
Mid-Western.—Chairman: Dr. Edward H. Cary, Medical Arts Bldg., Dallas, Texas.
Western.—Chairman: Dr. Frank A. Burton, Bank of America Bldg., San Diego, Calif.

American Otological Society

President: Dr. Francis R. Packard, 304 S. 19th St., Philadelphia.
Secretary: Dr. Thomas J. Harris, 104 E. 40th St., New York.

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* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.